Abhandlung

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The Late Neolithic Michelsberg culture – just ramparts and ditches? A supraregional comparison of agricultural and environmental data

Abstract: Der archäobotanische Forschungsstand zur Michelsberger und zur Bischheimer Kultur (5./4. Jahrtausend BC) wurde zusammengetragen und in Zusammenhang mit archäologischen, klimatologischen und biologischen Daten diskutiert. Verglichen mit Bischheim und dem Mittelneolithikum hat die Michelsberger Kultur ein reduziertes Kulturpflanzenspektrum genutzt, mit einem Schwerpunkt bei Getreideanbau. Die Herkunft des tetraploiden Nacktweizens konnte dabei noch nicht abschließend geklärt werden. Möglicherweise wurde der Anbau von Öl-/Faserpflanzen aufgegeben. Dieses reduzierte Michelsberger Spektrum findet sich interessanterweise etwas später analog im Verbreitungsgebiet der Trichterbecherkultur und bei den neolithischen Fundstellen auf den britischen Inseln. Klimatische Ursachen sind dafür wohl nicht als ursächlich anzusehen. Stattdessen könnte es sich nach den vegetationsgeschichtlichen und archäozoologischen Ergebnissen um eine kulturelle Entscheidung zu einem Landwirtschaftssystem mit Schwerpunkt bei der Viehzucht handeln.

Keywords: Westliches Mitteleuropa; Neolithikum; Bischheim; Michelsberg; Erdwerke; tetraploider Nacktweizen; reduziertes Kulturpflanzenspektrum.

Résumé: Les données carpologiques issues des sites de la culture Michelsberg et du complexe culturel de Bischheim (5th/4th millénaire BC) provenant de la France, de Belgique, du Pays-Bas et de l'Allemagne ont été mises en perspective avec des données archéologiques, climatologiques et des données biologiques. Au contraire des cultures archéologiques du complexe Bischheim et du Néolithique moyen les communautés paysannes du Michelsberg commençaient à cultiver un spectre des plantes réduit. Les résultats archéobotaniques rendent possible la reconstruction d'un mode de subsistance avec une orientation des activités vers l'élevage. Des changements importants viennent de l'exploitation surtout des céréales et peu des légumineuses et l'abandon de la culture des plantes oléagineuses, un spectre qui se retrouve également un peu plus tard dans la région de la Culture des vases à entonnoir et du Néolithique en Angleterre et en Irlande. Les recherches futures devront s'attacher à vérifier cette hypothèse. Peut-être est-ce un exemple d'une décision culturelle comme adaptation aux changements des besoins et des structures sociales?

Mots-clefs: Europe du centre-ouest; Néolithique; Bischheim; Michelsberg; camps à fossés interrompus; blé nu tétraploïde; spectre de plantes cultivées réduit.

Abstract: The archaeobotanical state of research from sites of the Michelsberg and the Bischheim culture (5th/4th millenium BC) in France, Belgium, southern Netherlands and Germany has been compiled and discussed in the

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context of archaeological, climatological and biological data. Compared with Bischheim and the Middle Neolithic the farmers of the Michelsberg culture had a reduced crop spectrum with emphasis on cereal growing. It is still under debate, from where the tetraploid wheat has been introduced. Possibly the growing of oil/fibre plants was abandoned by the Michelsberg farmers. Interestingly the same reduced crop spectrum is found somewhat later in the distribution area of the Funnelbeaker culture as well as in the Neolithic sites of Great Britain and Ireland. Climatic causes are not likely for this phenomenon. Instead, zoologial and botanical results point to an agricultural system with more emphasis on stock farming, which might have been based on a cultural decision.

Keywords: Western Central Europe; Neolithic; Bischheim; Michelsberg; causewayed enclosures; tetraploid naked wheat; reduced crop spectrum.

DOI 10.1515/pz-2014-0006

Introduction

The Late Neolithic Michelsberg culture belongs to a prehistoric time segment with important cultural changes comprising the neolithisation of north-western Central Europe as well as of the British Isles and parts of the northern Alpine foreland[1]. Recently archaeological and archaeobiological research was conducted within a Franco-German Michelsberg research program co-funded by the ANR (French National Research Agency) and the DFG (German Research Association) entitled "Emergence of social complexity: enclosures, resources and territoriality during the Neolithic"[2]. To answer the question of the interaction of man and environment, and to discuss the agricultural basis of the Michelsberg culture[3], in 2012 a workgroup was constituted, with the aim of compiling the archaeological and archaeobotanical state of research and discussing it in a supraregional context[4]. The results are presented in the following.

Archaeology

The Late Neolithic Michelsberg culture of the loess landscapes in western Central Europe succeeded the Middle Neolithic Rössen culture and the transitional Middle/Late-Neolithic Bischheim culture (Fig. 1). Following B. Höhn[5], Michelsberg phases II–V[6] probably lasted from about 4380/4340 until 3540/3530 cal BC. The precise dating of the Michelsberg phases is hampered by the plateaus of the calibration curve in the centuries around 4000 cal BC. Bischheim seems to be about 200 years older than Michelsberg, although too few ^{14}C-dates are available until now. As defined by Denaire *et al.*, Eisenhauer, Höhn, Jeunesse, Kuhlmann, Schier and Seidel[7], Bischheim starts at about 4600/4550/4500 cal BC, followed by a middle and younger phase until 4450/4420/4350/4300 cal BC[8].

According to the current archaeological state of research the Michelsberg culture has its primary origin in the Paris Basin in France, or more to the north in the border region of France and Belgium[9]. From there it spread to the Alsace, Belgium, the southern Netherlands, the Lower Rhine Area and further south into Germany. Sites from the earliest Michelsberg phase I are lacking in Hesse until now, for Baden-Württemberg it is still under discussion[10]. Perhaps Michelsberg started several hundred years later in these areas. Both Michelsberg and Bischheim have strong stylistic affinities with the western Chasséen of France[11].

1 Bradley 2007; Brown 2007; Denaire *et al.* 2011; Ebersbach *et al.* 2012; Furholt *et al.* 2011; Hinz/Müller 2012; Jeunesse *et al.* 2004; Jöns 2013; Louwe Kooijmans 2005; Schier 1993, 2009; Vanmontfort 2004.
2 *http://www.anr-mk-projekt.fr/spip.php?lang=en&page=sommaire*
3 "Culture" is meant here as "archaeological culture", comprising a typical combination of artefacts, archaeological features and archaeobiological finds in a certain distribution area (for the discussion see e.g. Lüning 1972).
4 Kreuz 2012. Participants of the workgroup have been Angela Kreuz and Eva Schäfer (Wiesbaden) for the region of Hesse, Elena Marinova (Brussels) for Belgium, Manfred Rösch and Tanja Märkle (Hemmenhofen) for Baden-Württemberg, Aurélie Salavert (Paris) for France, Tanja Zerl, Silke Schamuhn and Jutta Meurers-Balke (Cologne) for North Rhine-Westphalia. Charcoal results from France, not included here, have been provided by Aurélie Salavert. Other unpublished archaeobotanical data from France have not been available for this compilation.
5 Höhn 2002, e.g. 193.
6 After Lüning 1967/1968.
7 Denaire *et al.* 2011; Eisenhauer/Daszkiewicz 2003, 172 f., Fig. 4; Höhn 2002, 193; Jeunesse *et al.* 2004, 75; Kuhlmann 2008, 6; Schier 2009, 20; Seidel 2011.
8 Dating difficulties are apparent among the often high standard deviations of the ^{14}C-dates; see also the discussion of the dating of Cerny, Épi-Roessen, Proto-Menneville and Bischheim occidental in Vanmontfort 2004, 285 ff. and 350; Raetzel-Fabian 2006.
9 Badisches Landesmuseum Karlsruhe 2010; Dubouloz 1998, 19; Jeunesse 1998, 42 f.; Jeunesse *et al.* 2004; Knoche 2008, 126; Louwe Kooijmans 2005; Lüning 1967/1968; Schier 1993, 2009, 20; Vanmontfort 2004; more references there.
10 Höhn 2002; Regner-Kamlah 2010; Schlichtherle 1998, 170 ; Seidel 2012 and personal comm. 2013.
11 See references above as well as Gross 1990, 61 ff.

ca. cal BC	Archaeological culture	Neolithic
	Wartberg	
3.540/3.530		
	Michelsberg	Late
4.380/4.340		
4.450/4.420/4.350/4.300		
	Bischheim	Middle
4.600/4.550/4.500		
	Rössen Großgartach Hinkelstein	
4.900		
	Bandkeramik	Early
5.400		

Fig. 1: Chronology of the Early to Late Neolithic in the investigation area (absolute datings following Eisenhauer 2003; Geschwinde and Raetzel-Fabian 2009; Höhn 2002; Jeunesse 2004; Jeunesse et al; 2003; Knoche 2008; Kuhlmann 2008; Schier 2009; Seidel 2011; more references there)

More or less monumental causewayed enclosures – consisting of palisades, walls and ditches – are one of the most obvious characteristics of the Michelsberg culture[12]. They are situated either on hilltops or in the lowlands. Regularly the ditches have several interruptions or entrances. In addition, open sites without enclosures occur in the lowlands. At the end of Michelsberg the enclosures are built preponderantly on hilltops and perhaps developed a more defensive character[13].

It is still under discussion, which Michelsberg site types represent permanent settlements where people lived. Apart from settlement structures like pits, especially regular houses, of the Michelsberg culture are almost

12 Geschwinde/Raetzel-Fabian 2009; Jeunesse/Seidel 2010; Meyer 1992/1993; Seidel 2008; Wotzka 2000.

13 E.g. Biel 1998; Knoche 2008, 151; critical for the Wetterau region: Raetzel-Fabian 2006.

unknown[14]. Burnt daub with imprints of wood regularly provides evidence for building structures which – in contrast to earlier ones – left almost no traces in the ground and probably were now smaller – implying another form of residential sharing. The tradition of longhouses (Bandkeramik until Rössen) had (gradually?[15]) been abandoned by the Bischheim culture[16]. As for Michelsberg village structures, small houses in rows along roads are expected like those that existed before at the southern sites of Bischheim[17] and at the Neolithic sites of the northern Alpine foreland[18], but this has not been proven until now. Very few small buildings (partly sunken floor buildings) have been excavated[19]. In addition, 23 extremely large buildings have been uncovered in France at „Haute Chanvières" Mairy/Ardennes[20]. Three of these have been dated by ^{14}C to a younger Michelsberg phase (before 3800 cal BC). The character of this completely exceptional site is still under discussion. Unfortunately no archaeobotanical investigations have been conducted there.

As for the burials of the deceased, Michelsberg graves are also almost unknown. Rare exceptions are graves from Hofheim (Hesse), Bad Kreuznach (Rhineland-Palatinate), Stuttgart and Bruchsal (Baden-Württemberg)[21]. Instead, whole human skeletons as well as parts of one or several individuals are found above all in the ditches of the earthworks, but also in related pits.

According to anthropological data, the body height of Michelsberg men was between 1,63–1,75 m, of women 1,55–1,62 m[22]. Adults reached on average an age of 40 years, but occasionally ages of more than 60 years have also been determined. It appears that there is no differentiation in the deposition of males and females[23].

Based on the typo-chronology of the ceramics the Michelsberg culture is differentiated into five phases following Lüning and Höhn[24]. Several of the Michelsberg ceramic forms existed continuously for hundreds of years. Therefore, a site or a feature is archaeologically well datable only when it has an extensive pottery assemblage. In most cases it is only possible to distinguish between "earlier" and later "Michelsberg". Therefore in the following the archaeobotanical data are differentiated into "Earlier Michelsberg" (MK I and/or II) and "Later Michelsberg" (one or several phases of MK III–V) and "Michelsberg undifferentiated" (transition MK II/III included in this group). This makes sense as there are several changes in the material culture between Michelsberg phase II and IIIff. (e.g. the emergence of flat vessel bottoms, carinated bowls ["Knickwandschüsseln"] and barbotine ["Schlickauftrag"])[25].

Among the lithic finds (fragments of) grind stones indicate the availability of tools for preparing flour from cereals and pulses[26]. Michelsberg sites have produced flint tools of a larger dimensions than earlier in the Early and Middle Neolithic, so that for the first time the raw material had to be obtained from flint mines with shafts and gallery complexes over ten metres below surface[27]. Another lithic speciality are the Michelsberg tools made of mountain crystal[28]. As mountain crystal tools are not very useful from a functional point of view, a metaphoric use in ritual contexts is discussed[29].

Finds of long polished axes made of jade (jadeite) point in the same direction as they are not found as lost objects or settlement waste, but mostly as hoards[30]. The raw material came from extraction sites in the Alps between 1.500 and 2.400 m above sea level, at Monte Viso 70 km south-west of Torino and Monte Beigua north of Genova[31]. The difficult access to the raw material, the time consuming production of the tools, and the kind of deposition in hoards, as well as the rareness of these objects allows an interpretation as signs of a conceptual value

14 E.g. Vanmontfort 2004, 312.

15 Three exceptional Bischheim *longhouses* were found at three sites in the Lower Rhine area only (Arora 2002). One of them is not trapezoid – like the Rössen buildings – but rectangular. The dating of the buildings may be problematic, as other prehistoric periods are represented on the site.

16 E.g. Arora 2005; Herrmann/Jockenhövel 1990; Lüning 1981; Schamuhn in prep.; Schier 1993, 36; Schlichtherle 1988.

17 Biel 1984; Knoche 2008; Rademacher 1991; Schlichtherle 1988; Seidel 2012.

18 Matuschik 2011; Strobel 2000.

19 Examples in: Bergmann 2008; de Grooth 1991, 174; Höhn 2002; Knoche 2008; Richter in prep., 42 ff.; Schamuhn in prep.; Zeeb-Lanz 2002, 35.

20 Marolle 1998.

21 Probst 1991, 322; Regner-Kamlah written comm. 13. 5. 2013.

22 Wahl 2010, 97 ff.

23 Biel 1998; Herrmann/Jockenhövel 1990; Seidel 2008; 2012; Wahl 2008; 2010.

24 Lüning 1967/1968; Höhn 2002.

25 Contributions in Badisches Landesmuseum Karlsruhe 2010; Knoche 2008, 125 f., 143, 201; more references there.

26 Ramminger 2010.

27 E.g. de Grooth 1991; 2010; Kieselbach 2010; Lichardus 1998, 268; Louwe Kooijmans 2005; more references there.

28 Kieselbach 1998; Vanmontfoort 2004; see also Seifert 2012, 90 for the site of Zizers with Hinkelstein-Keramik in the Alpine Rhine valley, and Manen *et al.* 2004, 330 for the épicardiale Taï cave in the Gard valley near Avignon.

29 Roth 2000, 286 f.

30 E.g. recently discussed in Knoche 2013a.

31 Pétrequin *et al.* 2010; 2012.

within the ritual beliefs and practices of the Michelsberg society.

Digging in the mountains was restricted to the warm period, and it has been calculated the elaborate production perhaps did not exceed a dozen axes annually[32]. At any rate, as these axes obviously were not used for profane work, they could have been (masculine?) symbols, immediately recognisable by everyone and distributed by inter-elite exchange[33]. Maybe such tools indicate a certain ranking within Michelsberg society.

This phenomenon – like the other lithic finds mentioned above – implies long-distance transfer and supra-regional trade networks, which are also indicated by local stylistic adaptations and by finds (Kontaktfunde) of imported Michelsberg ceramics, e.g. ceramics from the Hegau region (Baden-Württemberg) at Hornstaad, Thayngen-Weier and Wangen-Hinterhorn/Lake Constance, as mineralogical analysis has shown[34]. A comparable phenomenon are the Michelsberg finds in the sandy regions of the southern Netherlands[35], in Belgium[36] and in Switzerland[37].

There were also routes for import from the south to the north as evidenced for example by – apart from the jadeite tools – pieces of antler tools (Hirschgeweih-Zwischenfutter), which are found all across the Alpine lakeshore sites but just as single finds in the Michelsberg earthworks, e.g. in Zornheim/Mayence (Rhineland-Palatinate) and in Heilbronn-Klingenberg (Baden-Württemberg)[38], indicating knowledge, but no fundamental adoption of this technical possibility. In contrast to the cultures of Southern Europe and the Alpine foreland, copper finds are almost lacking at Michelsberg sites[39], demonstrating again the existence of "cultural borders" of exchange in terms of certain objects and practices.

Material and methods

Archaeobotanical data from 31 Michelsberg investigated sites in France, Belgium, southern Netherlands and Germany are available (Fig. 2, Tab. 1–2). More than 800 samples from 228 archaeological features[40] have been investigated and about 36000 plant remains from 113 plant taxa determined (Tab. 4). In Tab. 2 the 27 archaeobotanical sites included in the calculations are listed[41]. All data were archived and circulated among the authors with the archaeobotanical database program of the Landesamt für Denkmalpflege Hessen/Wiesbaden *ArboDat* 2013.

The results from Bazoches (Yvelines), Cuiry-lès-Chaudardes (Aisne), Heerlen-Schelsberg (Limbourg) and Maastricht-Klinkers (Limbourg) could not be included in the calculations as the data are too few or not fully available[42]. There are archaeobotanical data from two further Michelsberg sites (Schorisse "Bosstraat" (Oost-Vlanderen) and Enines "Chêne au Raux" (Orp-Jauche, Brabant) which were not available, as they have not yet been published by the archaeologists responsible[43]. In addition, mixing of material from different periods may occur, especially within the ditches of earthworks. Therefore we had to exclude the data from Heilbronn-Klingenberg, where the plant remains are partly mixed with material from the earlier Bandkeramik settlement. This was indicated by several ^{14}C-dates and by Bandkeramik sherds regularly found within the ditches, but which unfortunately came to light *after* Stika had finished his work on the numerous plant-remains[44].

Clearly, the state of research is not satisfactory, particularly with regard to the unequal numbers of features and samples per Michelsberg phase (Tab. 2). In most cases the areas excavated were small and therefore comprise just a small number of features or samples as shown by Fig. 3 and 4. Therefore, the chance of finding plant remains and a representative number of taxa is further limited, and the available data may not be representative for the site as a whole.

Concentration values have been calculated for features with an available sample volume[45]. The density of charred seeds/fruits and/or chaff is rather low at Michelsberg sites, as expected under dry mineral soil conditions: less than one to 36 charred remains per litre per site, or 5,9 per litre from 149 pits and similar features. Even lower values (1,7/l) are calculated from the 154 samples from the Michelsberg banks and the ditches. More than 10 charred

32 Pétrequin *et al.* 2010; 2012.
33 Pétrequin *et al.* 2012, 1431 ff.
34 Knoche 2013b, 284, 287/foodnote 96; Lüning 1998, 281–285, Lüning 2000, 16 ff.; Matuschick 2011, 312; Schlichtherle 1998, 173; more references there.
35 Louwe Kooijmans 2005, 258.
36 Vanmontfoort 2004.
37 Doppler/Ebersbach 2011, 209.
38 Kieselbach 2010, 209; Schlichtherle 1998, 173 and pers. comm. 2013.
39 Pétrequin *et al.* 2010; 2012.
40 Features sampled are mostly ditches, ramparts, pits and postholes (Tab. 1). Former ground levels are not preserved, apart from the bases of the ramparts. Due to the dry mineral soil conditions just charred material is available.
41 Bruchsal-Aue BRA has three archaeological phases but is counted as one site here.
42 Bakels 1984; 1999, 74; 2003; Schreurs 1992, 140.
43 Corrie Bakels, Leiden, written comm. 12. 4. 2013.
44 Seidel 2008, catalogue; Stika 1996 a and b.
45 Sample volumes are lacking at three sites.

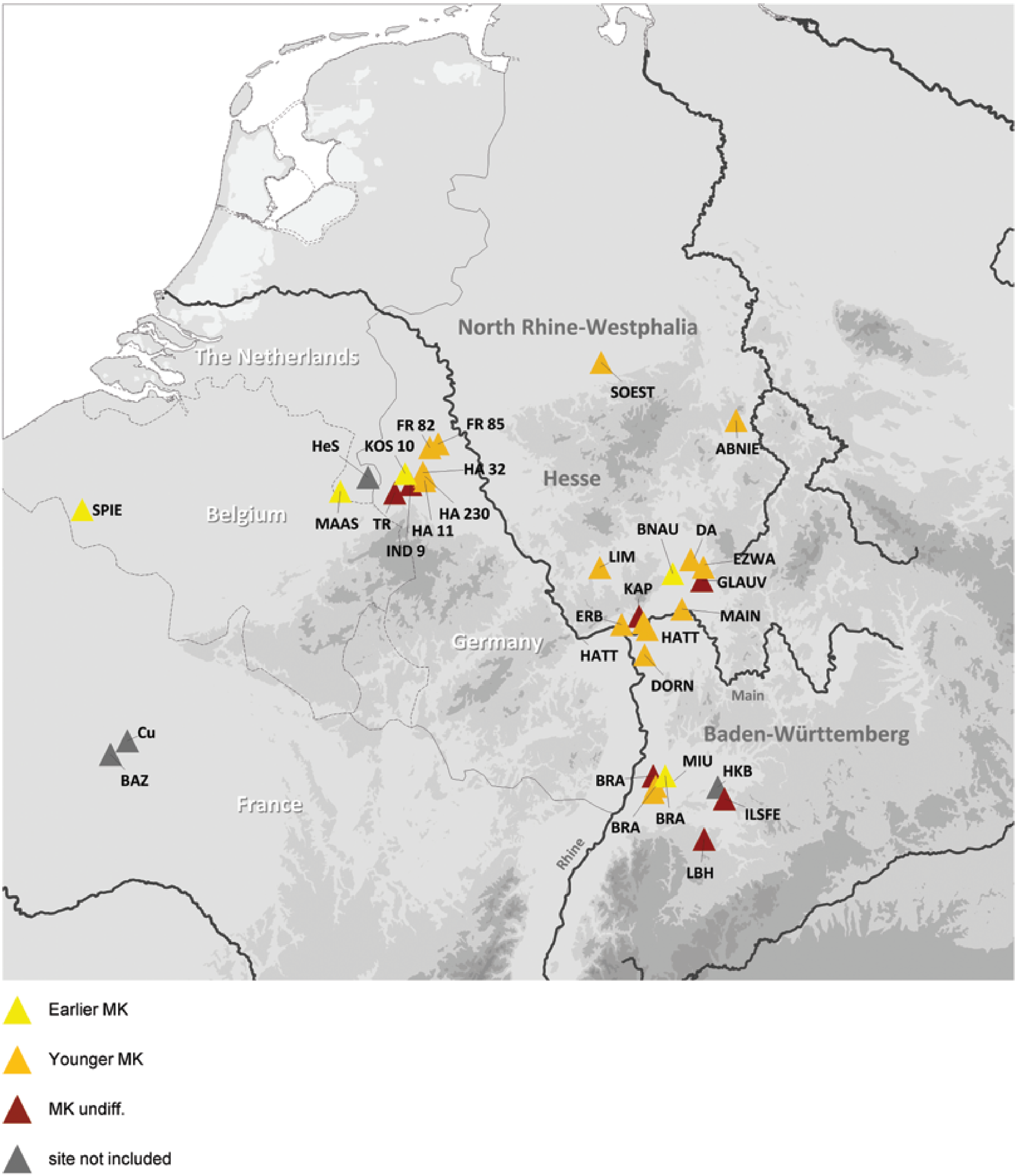

Fig. 2: Distribution map of the Michelsberg sites with archaeobotanical investigations. Calculations and statistics are based on sites, which are marked in yellow, orange or red according to their archaeological dating. Sites marked in grey are only mentioned in the text. Abbreviations: ABNIE Altenburg, Niedenstein; BAZ Bazoches, Aisne; BNAU Bad Nauheim; BRA Bruchsal, Aue; CU Cuiry-lès-Chaudardes; DA Dauernheim, Ranstadt; DORN Dornheim, Groß-Gerau; ERB Erbenheim, Wiesbaden; EZWA Echzell „Wannkopf"; FR 82 Jüchen-Garzweiler, Elfgen; FR 85 Jüchen-Garzweiler, Belmen; GLAUV Glauberg-Vorwall; HA 230, HA 11 and HA 32: Hambach, Niederzier; HATT Hattersheim; HeS Heerlen-Schelsberg; HKB Heilbronn-Klingenberg; ILSFE Ilsfeld, Ebene; IND 9 Inden Geuenich; KAP Kapellenberg, Hofheim; KOS 10 Koslar; LBH Leonberg-Höfingen; LIM Limburg, Greifenberg; MAAS Maastricht-Vogelzang; MAIN Maintal-Hochstadt; MIU Michaelsberg/ Untergrombach; SOEST Soest Altstadt; SPIE Spiere de Hel; TR Tank & Rast Aachen

remains per litre (calculated average) occur at no more than 33 % of the sites. Mass finds ("Vorratsfunde"), as defined by more than 100 pieces of crop seed remains per litre, have been found at three Michelsberg sites only: Jüchen-Garzweiler "Elfgen" and "Belmen" (naked wheat *T. aestivum* s.l./*durum*/*turgidum* and emmer *T. dicoccum*) and Ilsfeld "Ebene" (barley *Hordeum distichon/vulgare*).

As the archaeological excavations often have been constrained to the ramparts and the ditches of the enclosures, the question arose as to whether plant assemblages from Michelsberg refuse pits differ qualitatively from those from ditches and banks, especially with respect to the representation of the crop species. In order to answer this question a canonical correspondence analysis based on the number of taxa per Ecological Group per feature was conducted (Fig. 5–6)[46]. As expected there is a clear relationship between the volume investigated and the number of wild taxa found. On the other hand, it is important for the following argumentation that crop taxa (Ecological Group "crops" marked in yellow) are reasonably well represented (Fig. 5), as they occur in more than 65 % of the features investigated.

Fig. 6 shows the same canonical correspondence analysis. Again, every symbol marks one feature, now with the pits and the ramparts or ditches indicated as feature types. It is evident that there is no qualitative separation of the two feature groups. Therefore both can be used equally well for the calculations. In addition, for a better control of the results calculated, in the following in some cases the Michelsberg data are compared with data from 151 further prehistoric sites of the Hessian data base *ArboDat* (Tab. 3).

The Michelsberg crops

The Michelsberg farmers grew four cereals: emmer *Triticum dicoccum* and einkorn *T. monococcum*, as well as naked wheat, apparently the tetraploid form *T. durum*/*turgidum* (see chapter below), and barley *Hordeum distichon/vulgare* (Fig. 7). Interestingly there is no sure evidence for the cultivation of oil- or fibre-plants by the Michelsberg farmers until now[47]. This is surprising, as in the agricultural system of the southern contemporaneous neighbours of Michelsberg poppy *Papaver somniferum* and flax *Linum usitatissimum* clearly played a major role[48].

To counter the objection that the lack of oil plants is only due to their bad preservation as charred material[49], Tab. 3 shows the Hessian diachronic evidence for oil and fibre plants from 151 sites for other prehistoric periods. It is evident that even under the (from experience) bad preservation conditions of Bandkeramik sites, charred flax or poppy remains are present in the samples if these crop plants were in use[50]. Therefore the lack of oil plants within Michelsberg features could be of significance, although the state of research still needs improvement.

There is rather scarce evidence in the Michelsberg area for pea *Pisum sativum* and lentil *Lens culinaris*. Here again, a diachronic comparison of the frequencies per site reveals that pulses were indeed rare at Michelsberg sites compared for example with their occurrence at Bandkeramik sites (Tab. 3).

Origin of the tetraploid naked wheat?

As already noticed by C. C. Bakels[51], the Late Neolithic occurrence of tetraploid naked wheat is a break with the Middle Neolithic Rössen tradition of hexaploid naked wheat. The latter appeared in the investigation area at the end of the Bandkeramik culture[52]. Tetraploid naked

46 As for the definition of the Ecological Groups and their critical use see Kreuz (2004/2005, 122 Tab. 8 and 147 ff.).

47 There are just two single charred finds of "cf. *Linum usitatissimum*" at the site Bruchsal-Aue BRA in one sample of the ditch system, and another in a grave (determined by Manfred Rösch). As for the latter, it is an inhumation burial so that the charred material must come from other contexts. According to Birgit Regner-Kamlah, LDA Baden-Württemberg (written comm. 13. 5. 2013), there are secondary dislocations of Bandkeramik sherds, especially in the Michelsberg ditches. Therefore it is quite possible that Bandkeramik flax seeds went into the filling of Michelsberg features too. ^{14}C-datings of the seeds are needed to clarify the situation.
In addition there is the unusual find of 267 charred poppy seeds *Papaver somniferum* at Cuiry-lès-Chaudardes. As described by the author, they were partly indistinguishable from *Papaver rhoeas* (Bakels 1984, 4). In later publications they are just referred to as *Papaver somniferum* (Bakels 1991, Tab. 3/284; Bakels 1999). Most features of this site are again of Bandkeramik origin. Therefore an intrusion of Bandkeramik material into the Michelsberg pit cannot be ruled out. ^{14}C-datings of the seeds are needed here as well.

48 E.g. Jacomet 2007; Maier/Vogt 2001; Maier 2004; further references there.

49 E.g. Märkle/Rösch 2003.

50 The lack of opium poppy during the Earliest Bandkeramik is due to western Mediterranean influences not starting before the Flomborn period (LBK II; Bakels 1982; Kreuz 2010/2012). For the representation of crop species within the Michelsberg features see above and Fig. 5–6.

51 Bakels 2003, 23; see also Bakels 1990; 1994.

52 Kreuz 2010/2012, 141; Maier 1998.

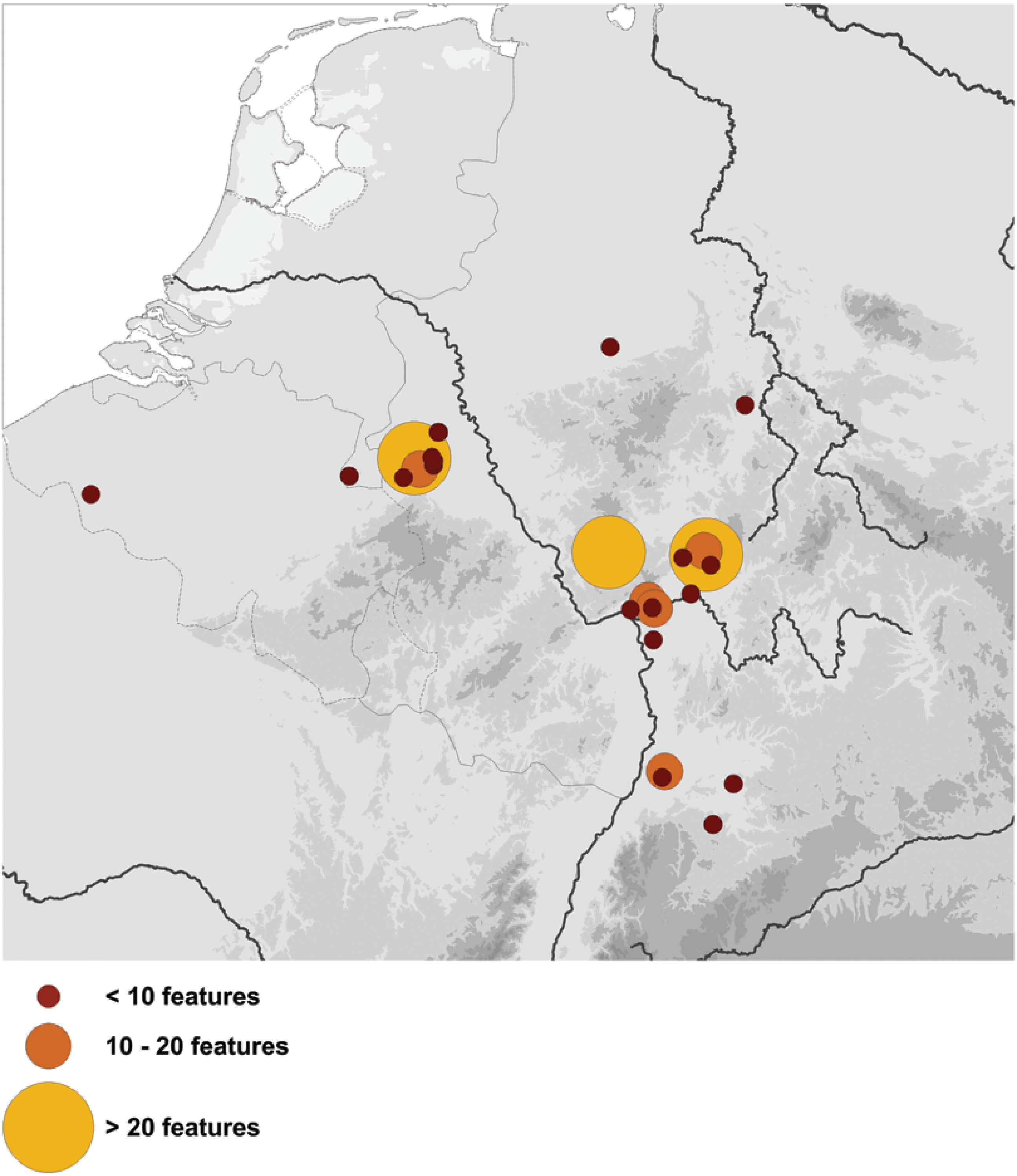

Fig. 3: Number of features investigated archaeobotanically mapped per Michelsberg site (see Fig. 4)

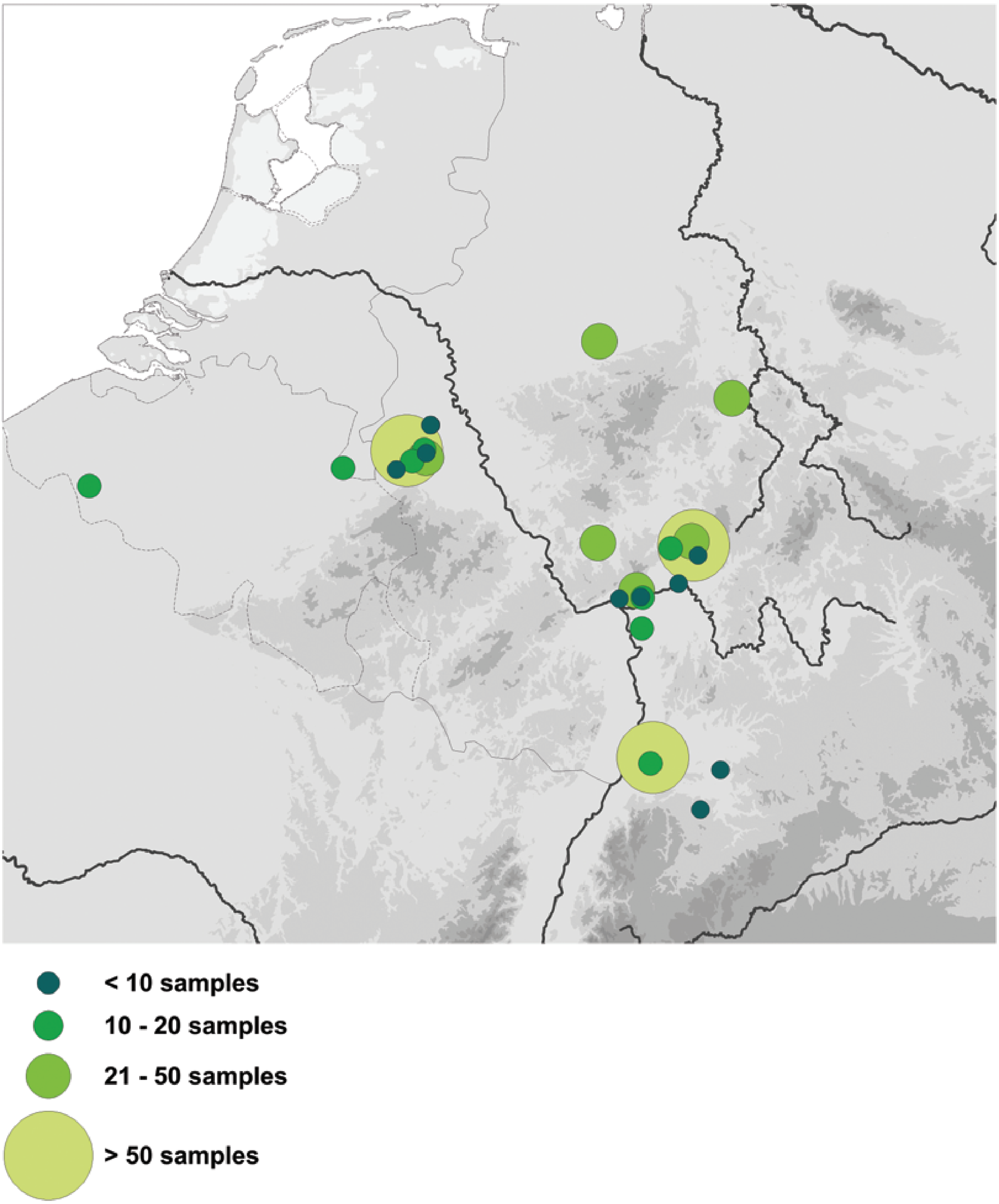

Fig. 4: Number of samples investigated archaeobotanically mapped per Michelsberg site (see Fig. 3). The state of archaeobotanical research for the Michelsberg culture is supraregionally unequal and therefore in need of improvement

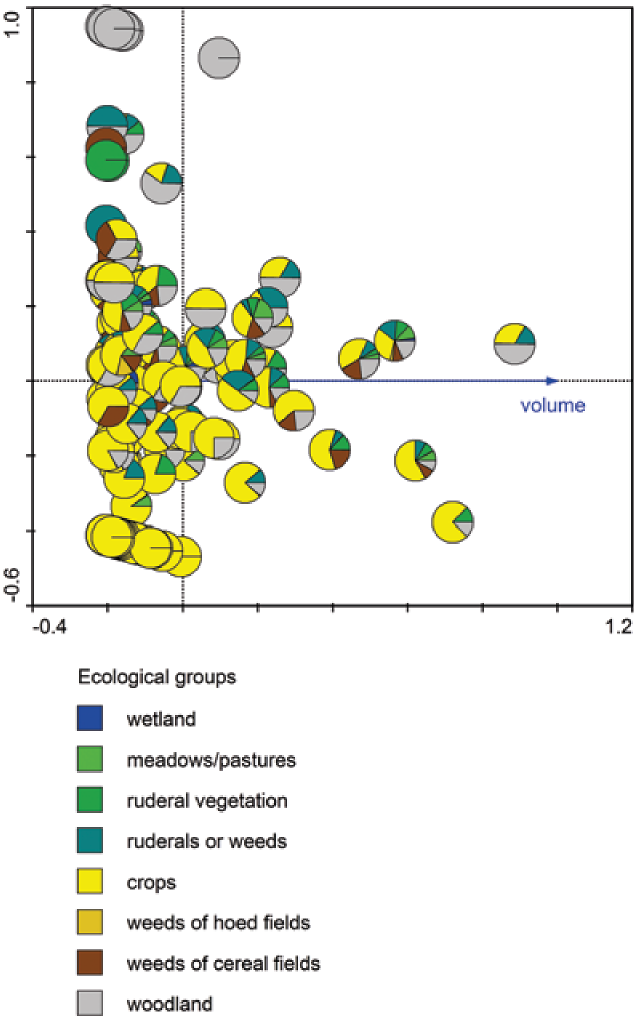

Fig. 5: Canonical correspondence analysis of features and the number of taxa per ecological group, constrained by the sample volume on the first axis. The pie charts represent the percentages of the numbers of taxa per ecological group per feature. Features with no sample volume available have been excluded. Marked in yellow are the crops, in orange and brown the "real weeds", in blue and green the other wild plants (see also Fig. 6)

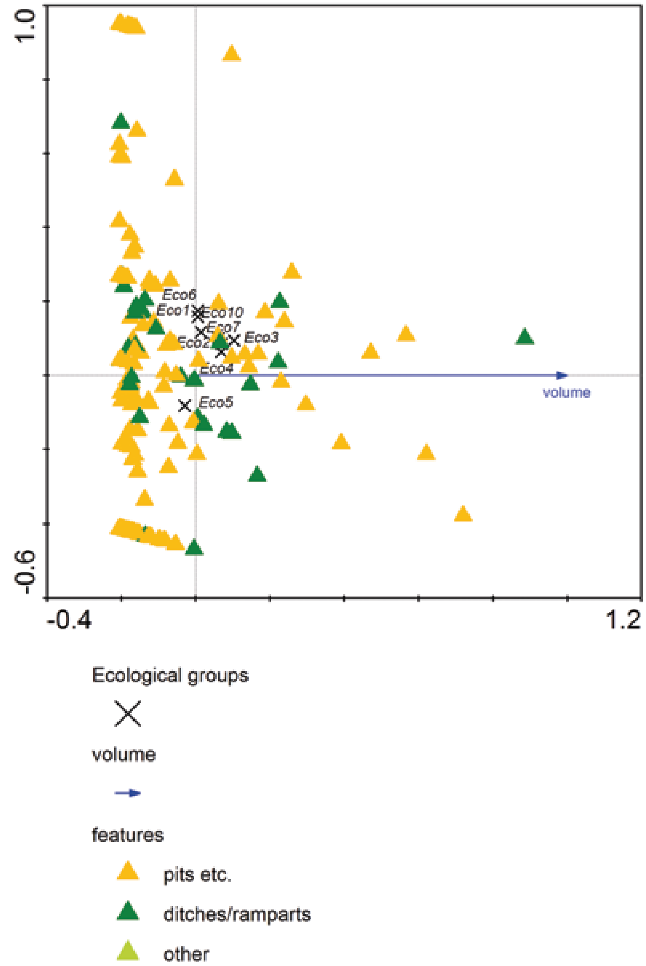

Fig. 6: Canonical correspondence analysis of features and taxa per ecological group, constrained by the sample volume on the first axis (see also Fig. 5). Here, features are classified according to the feature types *pits* (in the broadest sense), *ditches/ramparts* and *other* features. It is evident that there is no data separation related to the different feature types

wheat – the *T. durum/turgidum* form – has been identified by finds of rachis fragments at the two early Michelsberg sites Maastricht-Vogelzang/The Netherlands and Spiere/Belgium (MK I/II), as well as in younger Michelsberg features from Heilbronn-Klingenberg, Baden-Württemberg/Germany[53]. The question remains, where the Michelsberg farmers adopted their tetraploid naked wheat from.

Tetraploid naked wheat also is found in the early lakeshore sites of the northern Alpine foreland[54], and it has been discussed as an introduction from the South-West[55]. The earliest three of these lakeshore/island sites, Zürich "Kleiner Hafner" (layers 5A, B and 4A-C/D), Egolzwil 3 und Cham-Eslen – belonging to the Egolzwil culture – do not date earlier, but are probably contemporaneous with early Michelsberg. The two earliest layers of "Kleiner Hafner"

53 Bakels 2008; Bakels in Vanmontfort *et al.* 2001/2002; see also Bakels 2007, Tab. 19.1; Stika 1996a and b; Vanmontfort 2004, 52; for the rachis fragments see Fig. 7; the other Michelsberg sites produced evidence for grains of naked wheat only, which cannot be differentiated further.

54 E.g. Jacomet 2007; Martinoli/Jacomet 2002; Jacomet/Schlichtherle 1983; Maier 1996, 1999, 1998; see also Bakels 2003, 231.
55 E.g. Jacomet 2007, 246; Maier 1998.

Fig. 7: Charred plant remains from several Michelsberg sites (L length in mm; for the location of the sites see Fig. 2): **1** *Cornus sanguinea*, pit (L 4,0), AK42 DA 1995, Pr. 90–2B; **2–3** *Malus* cf. *sylvestris*: **2** seed (L 6,75), AK 42 DA 1995, Pr. 1–3B; **3** fragment of pericarp (L 4,9), AK 42 DA 1995, Pr. 75–3B; **4** cf. *Lens culinaris*, seed (L 2,5), AK 320 HATT, Pr. 15; **5–6** *Pisum sativum*: seeds **5** (L 3,6), AK 42 DA 1995, Pr. 45–6EF; **6** (L 3,6), AK 8 SU 1, Pr. 110; **7–16** *Hordeum distichon/vulgare*: **7–9** grain: dorsal, lateral, ventral (L 5,7), AK 331 MAIN, Pr. 301–32; **10–11** grain: dorsal, ventral (L 4,05), AK 4 Echzell, Pr. 69–7; **12–14** grain: dorsal, lateral, ventral (L 5,2), AK 42 DA, Pr. 72–128; **15–16** grain: dorsal, ventral (L 4,3), AK 331 MAIN, Pr. 301–32; **17–23** *Triticum monococcum*: **17–19** grain: dorsal, lateral, ventral (L 4,8), AK 42 DA 1995, Pr. 65–3B; **20–22** grain: dorsal, lateral, ventral (L 5,5), AK 42 DA 1995, Pr. 30–2B; **23** spikelet fork (L 2,1), AK 42 DA 1995, Pr. 34–5B; **24–35** *Triticum dicoccum*: **24–25** grain dorsal, ventral (L 5,8), AK 42 DA 1995, Pr. 1–2A; **26–28** grain: dorsal, lateral, ventral (L 5,9), AK 331 MAIN, Pr. 301–32; **29–31** grain: dorsal, lateral, ventral (L 4,95), AK 331 MAIN, Pr. 304–25; **32** grain: lateral (L 3,5), AK 276 BN-Sie, Pr. 213; **33** grain: lateral (L 5,65), AK 331 MAIN, Pr. 304–25; **34** spikelet fork (L 1,8), AK 42 DA 1995, Pr. 34–5B; **35** glume base (L 2,0), AK 42 DA 1995, Pr. 45–6EF; **36–37** *Triticum aestivum* s.l./*durum/turgidum*, grain: dorsal, ventral (L 4,55), AK 42 DA 1995, Pr. 72–2B; **38** *Triticum durum/turgidum*, grain: dorsal, determined by rachis segments, material from Spiere (prov. West-Vlaandern/Belgium); **39–50** *Triticum aestivum* s.l./*durum/turgidum*: **39–41** grain: dorsal, lateral, ventral (L 4,0), AK 281 KAP 2008, Pr. 8; **42–44** grain: dorsal, lateral, ventral (L 3,2), AK 276 BN-Sie 2008, Pr. 213; **45–46** grain: dorsal, lateral (L 3,3), AK 276 BN-Sie, Pr. 213; **47–50** grain FR 2001 (Zerl 2003, Fig. 17); **51–52** *Triticum aestivum* s.l., rachis segments; **53–63** *Triticum durum/turgidum* rachis segments: **53–58, 63**, Heilbronn Klingenberg; 59–62 FR 2001 (Zerl 2003, Fig. 19–20). (pictures: 1–5, 7–11, 15–37, 39–46 S. Gehner, HessenArchäologie; 6, 12–14 H. v. Schlieben, HessenArchäologie; 38 C. C. Bakels unpubl.; 47–50 (Fig. 17), 51–52 (Figs. 22–23), 59–62 (Figs. 19–20) Zerl (2003); 53, 63 Manfred Rösch/Tanja Märkle unpubl. (3631–3639); 54–58 Stika (1996, Fig. 25 detail)

in Zürich are dated by E. Gross[56] between 4375 and 4250 cal BC, corresponding approximately with Michelsberg phase II[57].

Tetraploid naked wheat also comes from the subsequent Early Cortaillod sites of Central Switzerland (corresponding to phase MK II too), as well as at Lake Constance at Hornstaad-Hörnle IA (corresponding to MK II/III[58]), and at the sites of the Pfyn/Altheim group of southern Bavaria[59], which is parallel to later Michelsberg (after 3.900 cal BC; MK III ff.).

The Rössen culture marks the end of the Middle Neolithic in the loess landscapes of the investigation area, where in between Rössen and Michelsberg the transitional Bischheim culture occurs (Fig. 1)[60]. Both Bischheim and Michelsberg ceramics were influenced stylistically by the western Chasséen traditions[61]. Notably, tetraploid naked wheat is already present in sites of the Bischheim culture[62].

In contrast to the Michelsberg farmers, those from the Bischheim group cultivated a more diverse crop spectrum with opium poppy *Papaver somniferum* and flax *Linum usitatissimum*, as well as naked barley *Hordeum distichon/vulgare*, hexaploid and tetraploid naked wheat *Triticum aestivum* s.l. and *Triticum durum/turgidum*, glume wheats *Triticum dicoccum* and *monococcum*, lentil *Lens culinaris* and pea *Pisum sativum* as additional crops[63]. As Bischheim is earlier than Egolzwil and Michelsberg, Bischheim and/or its cultural roots could have been a catalyser for the agricultural adoption by the Egolzwil lakeshore settlers of the northern Alpine foreland, where tetraploid naked wheat and oil plants have been found regularly from the second half of the 5th millenium cal BC onwards. Actually, Egolzwil pottery shows similarities to those of Bischheim, but also direct contacts to the (South-) West[64]. This leads to the question of the formation of farming settlements in the first half of the 5th millennium cal BC in the Alpine region of Switzerland and France.

Unfortunately, in France and Switzerland the state of archaeological research for the period prior to the lakeshore settlements is rather vague and archaeobotanical investigations are rare until now, although promising new investigations have just started[65]. Some sites on mineral soil with archaeological traces of contact to the North and/or South-West during the 5th millennium cal BC will be considered here.

The earliest of these sites with archaeobotanical investigations is situated in the Alpine Rhine valley at Zizers-Friedau near Chur (GR, Switzerland), and dates to the first half of the 5th millennium cal BC. In addition there is the find of some sherds of a small Rössen vessel (15 cm height, 17 cm diameter) from the castle of Gutenberg-Balzers (Liechtenstein) nearby in the Rhine valley, 50 km from Lake Constance and of unclear taphonomic origin[66].

The site Zizers-Friedau is situated on the dry mineral soil of an alluvial fan (“Rüfenfächer”) at the border of the Rhine terrace. It produced a culture layer, on average 10 cm thick, with two activity zones comprising hearth pits with heating stones and lithic finds, as well as 15 round-bottomed pottery vessels reminiscent of the Hinkelstein style, in part influenced stylistically from the area south of the Alps[67]. In this context the provenance of the lithic finds is of interest, coming from, among other areas, Bavaria (8 %) and Upper Italy (11 %)[68].

Depressions in the ground of 4–25 cm diameters are no evidence for the structure of a building at Zizers. Unexplained are 36 small “hills” consisting of humic material with diameters of 20–60 cm protruding from the culture-layer[69]. The bone fragments, which perhaps were so small due to the soil conditions, could not be determined. Important finds are 2539 charred plant remains, including 365 barley grains *Hordeum distichon/vulgare*, 22 grains and 56 chaff-remains from emmer *Triticum dicoccum*, three grains and six chaff remains from einkorn *Triticum monococcum* as well as five grains of naked wheat *Triticum aestivum* s.l./*durum/turgidum*, 21 seeds of pea *Pisum sativum*

56 Eda Gross, Amt für Denkmalpflege und Archäologie Zug, written comm. 31. 5. 13.
57 Following Höhn 2002.
58 Following Matuschik 2011.
59 Jacomet 2007, 244 f.; Rösch 2013; more references there.
60 E.g. Herrmann/Jockenhövel 1990, 151 ff.; Jeunesse 1998; Lüning 1981; Schier 1993; critical e.g. Raetzel-Fabian 2006, 181.
61 E.g. Gross-Klee 1998; Jeunesse *et al.* 2004, maps in Fig. 186 ff.; Knoche 2008, 123 ff.; Vanmontfort 2004.
62 Evidence comes from Schernau (Hopf 1981), Creglingen-Frauental (Rösch 2014) and Oberderdingen-Großvillars “Seeberg” (M. Rösch unpublished data) and from two sites near Jüchen-Garzweiler/Lower Rhine valley (Frimmersdorf 2001/103 and Frimmersdorf 137; Zerl 2003; see also Arora/Zerl 2004; Päffgen/Zerl 2005). In addition there is a find of three rachis remains from the probably “late Rössen” site Oespeler Bach, feature 202. There is a ^{14}C-date from the same feature (KN-4573, 4488–4374 cal BC [1σ], which might be contemporaneous with Bischheim (Brink-Kloke/Meurers-Balke 2003, Tab. 1, determinations by Rainer Pasternak).
63 Becker 1991; Hopf 1981; Rösch 2014; M. Rösch unpubl.; Zerl 2003, 62.
64 E.g. Denaire *et al.* 2011, 35 ff., Fig. 11 ff.; for the discussion of Neolithic cultural influences see e.g. Jeunesse/van Willigen 2010.
65 Stefanie Jacomet, Basel, personal comm. September 2013.
66 Commented critically by the author himself (von Merhart 1936, 29).
67 Seifert 2012.
68 Seifert 2012, Fig. 13.
69 Seifert 2012, 80 f.

and one seed of opium poppy *Papaver somniferum*[70]. This crop spectrum fits well into the Middle Neolithic tradition from the loess landscapes more to the North (see above). Due to the lack of rachis fragments the naked wheat could not be differentiated further. ^{14}C-dates obtained from hazelnut shells gave an age of around 5900 BP[71].

A further important site of the first half of the 5th millenium cal BC that has been archaeobotanically investigated is situated at Sion in the Rhône valley east of Lake Geneva (lac de Genève) in the canton Valais (Wallis)[72]. The naked wheat at this site was again preserved as grains only. This important archaeobotanical material was recovered long ago by the late Karen Lundström-Baudais, and is now under examination by Lucie Martin, Université de Genève[73]. The results have to be awaited from there.

Three further Neolithic sites situated in the region of the Alpine Rhine valley date to the second half of the 5th millenium cal BC (Sevelen-Pfäfersbüel and Sevelen-Geissberg ("Epi-Rössen"[74]), and Schellenberg-Borscht[75] ("Epi-Rössen" until "Horgen")[76].

Sevelen-Pfäfersbüel is a well-documented hill-top site bordering the Rhine valley east of Lake Zürich (4.360–4.040 cal BC; contemporaneous with Early Michelsberg and Egolzwil), again with a culture layer, based here on the local loess sediment. The culture layer contained several fire-places with heating stones, a considerable amount of ceramics (type Borscht, Aichbühl and Lutzengüetle/Early Pfyn), as well as lithic artefacts with supraregional proveniences[77]. At this site the reconstruction of a house is not convincing, as there are no clear building structures and the distribution of the artefacts and several fireplaces in an excavated area of ca. 20 m^2 does not really sustain the hypothesis[78].

The bone artefacts and fragments identified belong to wild and domestic animals, with cattle dominating, followed by pig and in smaller quantities sheep/goat. This result is interpreted by R. Ebersbach as representing the "Balkan tradition" of stock-breeding, in contrast to the dominance of sheep/goat at the sites from southern and western Switzerland[79]. Rigert *et al.*[80] discuss the relationship of different cultural influences based on the typochronology of the ceramics, concluding the "Epi-Rössen" finds resemble more the Late Neolithic group of Aichbühl in south-western Germany than the contemporaneous Egolzwil culture of the Swiss Plateau ("Mittelland").

The archaeobotanical investigation of the two samples from Sevelen-Pfäfersbüel by Akeret revealed crop finds, with barley *Hordeum distichon/vulgare*, naked wheat *Triticum aestivum* s.l./*durum/turgidum*, emmer *Triticum dicoccum* and einkorn *Triticum monococcum*, as well as flax *Linum usitatissimum* and opium poppy *Papaver somniferum*. Due to the lack of rachis fragments, again the naked wheat could not be determined further. In this case a tetraploid form could be expected, as is known from the Egolzwil sites at the lakeshores[81].

Further Neolithic sites on mineral soil have been partly excavated on the plateau de Bevaix, near the Lac de Neuchâtel. Two of these sites have been investigated archaeobotanically: Saint-Aubin (parcel: Derrière la Croix) and Bevaix (two neighbouring parcels: Les Maladiéres and Treytel-Á Sugiez)[82].

The older features of Saint-Aubin and Bevaix represent a site type possibly not occupied permanently[83]. As for the "Néolithique moyen I" of Saint-Aubin/Derrière la Croix, again a culture layer with a maximum thickness of 15 cm has been excavated lined by a row of five menhirs, and with several fire-places and hearth-pits with cooking stones[84]. Notably the proveniences of the lithic finds from this site point to the North-East, judging by imports from the region of Basel[85]. The site of Bevaix, with similar features to Saint-Aubin, is convincingly interpreted by the archaeologists in charge as a site for ritual, sacred functions[86].

At Saint-Aubin, apart from barley *Hordeum distichon/vulgare*, emmer and einkorn *Triticum dicoccum* and *monococcum*, pea *Pisum sativum* and one seed of flax *Linum*

70 Brombacher/Vandorpe 2012.
71 Brombacher/Vandorpe 2012, 95.
72 Ebersbach *et al.* 2012, Fig. 6 and Tab. 2; According to Winiger 2009 (e.g. Fig. 14) further Neolithic sites in this region date to the second half of the 5th, or to the first half of the 4th millenium cal BC.
73 Personal comm. by Stefanie Jacomet/IPNA Basel, September 2013.
74 "Epi-Rössen" is characterized by so-called "Kugelbecher" of the Borscht-Izighofen type from the site Schellenberg-Borscht (Rigert *et al.* 2005, 42).
75 Seifert 2004.
76 Following the maps in Denaire *et al.* 2011 and Seifert 2012, Fig. 1; discussed also in Rigert *et al.* 2005.
77 Rigert *et al.* 2005, 52 ff.
78 Rigert *et al.* 2005, 46 and Fig. 6–7.
79 Ebersbach in Rigert *et al.* 2005, 60.
80 Rigert *et al.* 2005, 60 ff.
81 Akeret in Rigert *et al.* 2005, 57 f.; Jacomet 2007.
82 Akeret/Geith-Chauvière 2003; Akeret/Geith-Chauvière 2011a, see 29 ff. and Fig. 13; Akeret/Geith-Chauvière 2011b; Grau Bitterli/Fierz-Dayer 2011; Wüthrich 2003.
83 Akeret/Geith-Chauvière 2003, 292; Grau Bitterli/Fierz-Dayer 2011, e.g. 345 ff.
84 Wüthrich 2003, e.g. Fig. 87.
85 Wüthrich 2003, Fig. 109.
86 Grau Bitterli/Fierz-Dayer 2011, e.g. 345 ff; see also the inpressive pictures of the menhirs and surrounding features p. 95 ff.

usitatissimum, as well as tetraploid naked wheat *Triticum durum/turgidum* have been identified within four structures. At Bevaix oil plants are lacking, but instead pea *Pisum sativum* was identified. Tetraploid naked wheat has also been found at Bevaix/Les Maladières, within somewhat younger features archaeologically dated to Cortaillod Ancien[87].

The excavation at Saint-Aubin gave ^{14}C-dates in the range of 4.800–4040[88]. Unfortunately just two of these dates from features St-39 and St-28, which did not contain remains of tetraploid naked wheat, belong to the first half of the 5th millenium cal BC, while seven to eight dates are later, clearly belonging to the second half of the 5th millenium[89]. Therefore this site does not allow to date the introduction of tetraploid naked wheat into the Swiss Plateau.

To summarise, the earliest archaeological sites of the 5th millenium cal BC in France and Switzerland compiled by Denaire *et al.* and Ebersbach *et al.*[90] are either cave sites and abri (often published by the excavators without clear profile drawings or plans), which might have been hunting or (later) herdsmen camps[91], or they comprise mineral soil sites consisting of "culture-layers" with fire places and hearth pits with cooking stones and sometimes menhirs (see above), which do not fit to the known Middle Neolithic tradition of, for example, Rössen settlement structures. On the contrary, hearth pits with charcoal, heating stones and flint remains are a common phenomenon at Mesolithic sites, for example in western Lower Saxony and in the northern Netherlands, as recently mapped by Fries *et al.*[92]. In this context the widespread phenomenon of the stone bordered graves ("cistes de Chamblandes")[93] in midwest France and Switzerland is remarkable, beginning in the first half of the 5th millennium BC and never appearing combined with "real" settlement structures. This phenomenon is connected by Denaire *et al.*[94] with the round-bottomed and – in contrast to the Chasséen – undecorated pottery of the Saint-Uze style (syn. Proto-Cortaillod, Chasséen ancien).

Possibly the phenomenon of the "Chamblandes", as well as the "fire place-sites" mentioned above, represent a transitional phase of a local (Late-Mesolithic?) population, influenced by the north and the south-west. This "substrate" may in the end have led to the farming system of the Swiss Egolzwil and subsequent lakeshore settlers that differed, for example, to that of the earlier settled loess landscapes in the North[95].

During the 5th millenium cal BC (and before), thanks to the archaeological finds there is no doubt about direct or indirect trans-Alpine exchanges and cultural influences: on the one hand with the culture of Bocca Quadrata, e.g. from the southern Alpine foreland through the Adige-/South Tyrol (Etsch-Tal) and the Rhône-valleys[96], on the other hand via long distance contacts to the north, for example with the Middle-Neolithic Hinkelstein and Rössen contexts (see above).

Due to the present state of research, the diffusion of tetraploid naked wheat to the North cannot be traced at the moment. Different scenarios are possible: Jacomet, Maier and Schlichtherle[97] discussed a possible origin of tetraploid naked wheat in the west-mediterranean Cardial culture. Definite finds with rachis remains are in fact known from La Draga in Catalonia/Spain, dating to the second half of the 6th millenium cal BC[98]. Tetraploid naked wheat is expected to be found in southern France from the early Neolithic onwards. Unfortunately, the naked wheat finds from there have so far been just grains, which cannot be determined further[99].

During the 5th millenium cal BC tetraploid naked wheat may have been distributed as far as the Paris basin in northern France, and from there to the Bischheim and Michelsberg zone of Germany. Alternative routes might have run either along the Rhône/Saône and/or the Doubs/Rhine valleys (Belfort Gap), or crossing the Alpine region

87 Akeret/Geith-Chauvière 2011a, 29 ff. and Fig. 13.
88 4810–4460, 4550–4250, 4500–4220, 4780–4400, 4460–4040 and 4770–4360 cal BC; Akeret/Geith-Chauvière 2003, 285; Wüthrich 2003, 104 f., Fig. 132 and Fig. 133.
89 Wüthrich 2003, 104 f., Fig. 132–133.
90 Denaire *et al.* 2011, Fig. 9; Ebersbach *et al.* 2012, Tab. 1–2; see also Manen *et al.* 2004.
91 See e.g. Chaffenet/Cordier (1999) as well as the discussion in Bréhard *et al.* (2010) for the Rhône valley.
92 Fries *et al.* 2013, e.g. Fig. 7.
93 Gallay 1977; contributions in Moinat/Chambon 2007.
94 Denaire *et al.* 2011, 38.
95 See also the "pre-Cortaillod" datings in Boisaubert *et al.* (2008, Annexe 2.2) and the interesting contextual discussion in Nicod/Coutard (2009) of the "Grotte du Gardon", west of lake Geneva at the northern border of the Rhône valley, and by Thiériot and Saintot (1999) from the pit with "Saint-Uze" and "Bocca-Quadrata" material (2. half of 5th millenium cal BC) at Estournelles à Simandres south of Lyon/Rhône, which is interpreted as trans-Alpine "French/Italian" exchanges with the regions of Piedmont and Liguria; see also Winiger (2009, 268 ff.) for Saint-Léonard Sur-le Gran-Pré/Valais/Rhône and the typo-chronologial relationship with the Chasséen.
96 E.g. Denaire *et al.* 2011; Nicod/Coutard 2009, 520; Nisbet 2008; Rottoli/Castiglioni 2009; Thiériot/Saintot 1999.
97 Jacomet/Schlichtherle 1983; Jacomet 2007, 246; Maier 1996, 1998.
98 Ferran Antolín, written comm. 13. 8. 2013; Antolín/Buxó 2011; Bogdanovic/Piqué 2012, Tab. 1; Buxó 2007; Pena-Chocarro *et al.* 2005.
99 E.g. Bouby in Manen *et al.* 2004; Maier 1998, 213 and Tab 1; Marinval 1988, 2007.

from the south-west, for example by the Rhône and Aare valleys and/or through the Alpine Rhine valley.

Egolzwil and the subsequent cultures of the Alpine lakeshore sites either introduced tetraploid naked wheat by direct contact from south-west France, or from the Bischheim zone in the North. In any case, the material culture of Bischheim and Michelsberg was apparently influenced by French cultural connections (Chasséen complex)[100].

In this context it may be significant that the earliest Michelsberg sites seem to provide more evidence of naked wheat than the younger sites. Fig. 8 shows a comparison of the numbers of cereal grain finds mapped for 29 Michelsberg sites. Four sites with too few grains had to be excluded, therefore the database used is smaller. It is evident that there is a slight difference between the areas to the right and the left of the river Rhine, which might be related to the different archaeological dating of the sites (Tab. 1). A bit more more naked wheat occurs in the earlier sites to the west, and more glume wheat at the younger sites (MK III ff.) in the east. A further hint in the same direction is given by a correspondence analysis based on the abundance of grain/seed numbers per site (Fig. 9). Again a certain tendency of separation is evident, indicated by the position of the earlier Michelsberg sites marked in yellow influenced by naked wheat[101].

A better archaeobotanical data set is needed in the future for testing this hypothesis. In the following it will be discussed if all the developments of crop growing mentioned above were driven by cultural decisions or by ecological factors, for example climatic development?

Climate as a trigger for agricultural developments?

A progressive decline in summer temperature from the Middle Holocene is documented by pollen and plant macrofossil data in Northern and Central Europe[102]. The age of the Michelsberg culture coincides with periods considered to be characterized by rapid global climatic changes (RCC). The interval 6000–5000 cal BP (4050–3050 cal BC) features North Atlantic icerafting events[103], alpine glacier advances[104] and stronger westerlies over the North Atlantic and Siberia[105]. A data set of radiocarbon, tree-ring and archaeological dates obtained from sediment sequences in 26 lakes in the Jura mountains, the northern French Pre-Alps and the Swiss Plateau was used by Magny[106] as evidence of a rather unstable Holocene climate punctuated by phases of higher lake levels, including at the beginning and at the end of the Michelsberg culture: 4400–4310, 3700–3250 cal. BC/6350–5900, 5650–5200 cal. BP (Magny episodes 10 and 9, corresponding in part with the Piora or Rotmoos I and Piora or Rotmoos II oscillations[107]; Fig. 10). However, such global climatic events could have caused locally different effects. On the scale of western Central Europe they are not always clearly detectable[108].

The evidence from the Eifel maar lakes provides an opportunity of tracing possibly climate induced environmental change[109]. Kühl and Moschen[110] investigated pollen and oxygen isotopes of moss cellulose ($\delta^{18}O_{Spagnum}$) from the peat bog "Dürres Maar" in the Eifel (low mountain range, Germany, 450 m a.s.l.): "Around 6000 cal BP [4050 cal BC], the pollen-based reconstructions indicate mean July temperatures ~1 °C decreased, which is confirmed also by $\delta^{18}O_{Sphagnum}$ values pointing at decreasing continentality for this period … After ~5500 cal BP [3550 cal BC] the pollen-based reconstructions indicate little variability in summer temperature, while, winter temperatures show several pronounced cold excursions (lowering of the mean January temperature with ~2–4 °C) in this period, which was likely accompanied by changes in precipitation patterns indicated by the $\delta^{18}O_{Sphagnum}$ values"[111]. The latter coincides with the end of the Michelsberg period.

The occurrence of *Hedera* and *Viscum* pollen types in the diagrams of the Vogelsberg mountain area, Hesse, can be interpreted as locally grown as they are insect pollinated taxa. Their Neolithic occurrence there is evidence for more favourable climatic conditions than exist today[112]. *Viscum* vanishes in the early Subboreal (around 3700 BC), which probably indicates a decrease of summer

100 E.g. Gross 1990, 61 ff.; Jeunesse *et al.* 2004; see also the discussion of Michelsberg vessels with perforated ledges in the context of the French Neolithic (Knoche 2013b, e.g. 293).
101 The fact that the site of Bruchsal Aue is not in the "right" position among the earlier sites might be due to the fact that there is also a mixing of different MK phases (and Bandkeramik, Regner-Kamlah written comm. 13. 5. 2013) on site, therefore we cannot be completely sure of the archaeological dating of the samples from there.
102 Brewer *et al.* 2009; Davies *et al.* 2003.
103 Bond *et al.* 1997; Bond *et al.* 2001.
104 Denton/Karlen 1973; Haas *et al.* 1998; Nussbaumer *et al.* 2011.
105 Meeker/Mayewski 2002.
106 Magny 2004, 2013; see also Magny *et al.* 2006.
107 Magny 2013, Fig. 4; Seidel 2012, 300.
108 E.g. Bittmann 2001, 102 ff.; Wanner *et al.* 2008; Wanner *et al.* 2011.
109 Litt *et al.* 2009; Kühl/Moschen 2012.
110 Kühl/Moschen 2012
111 Kühl/Moschen 2012, 1075 and Fig. 4.
112 Schäfer 1996, 180.

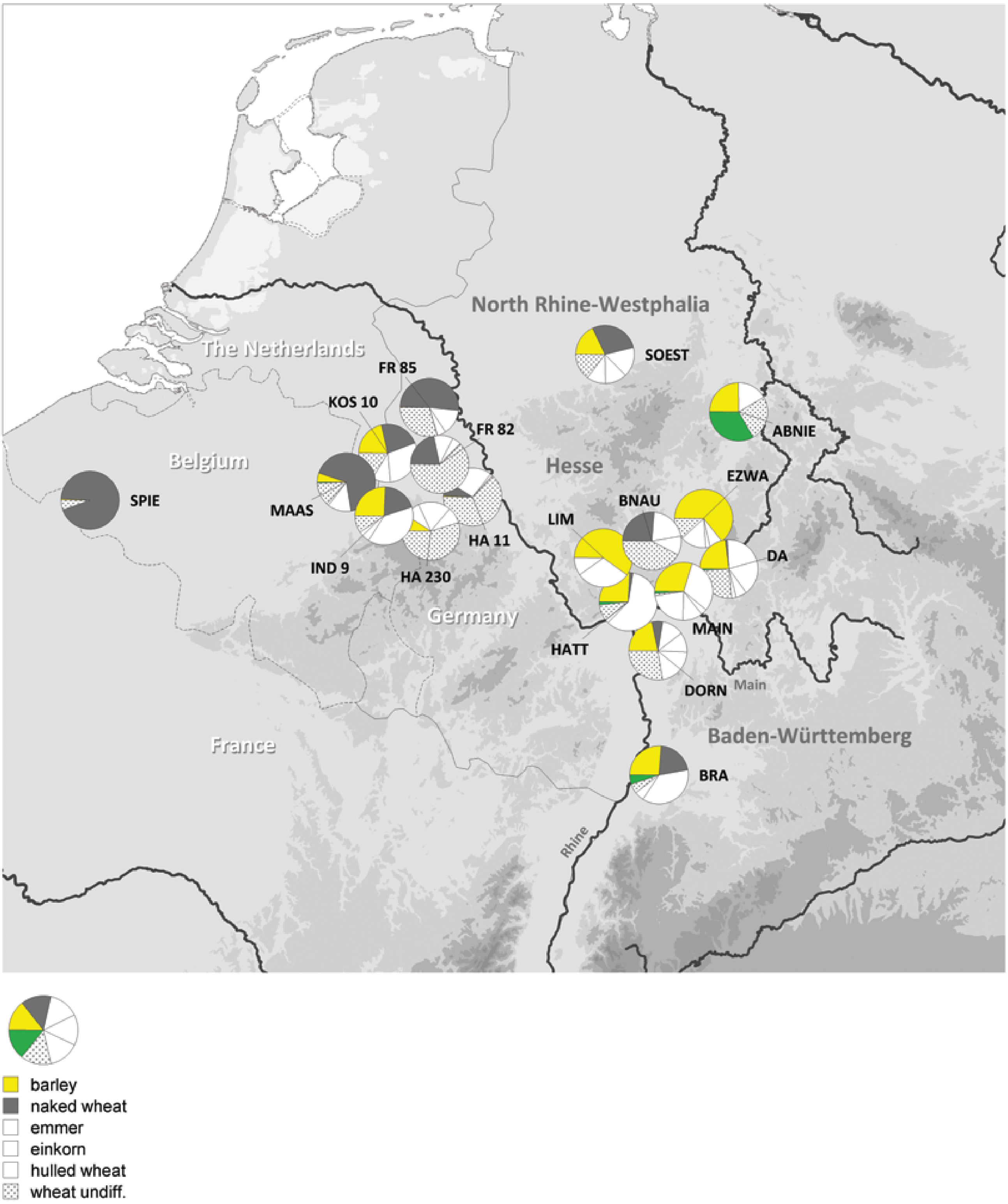

Fig. 8: Percentages of crop species (number of seeds) mapped per site with a minimum of ten crop seeds. Abbreviations: ABNIE Altenburg, Niedenstein; BNAU Bad Nauheim; BRA Bruchsal, Aue; DA Dauernheim, Ranstadt; DORN Dornheim, Groß-Gerau; EZWA Echzell „Wannkopf"; FR 82 Jüchen-Garzweiler, Elfgen; FR 85 Jüchen-Garzweiler, Belmen; HA 230 Hambach; HA 11 Hambach, Niederzier; HATT Hattersheim; IND 9 Inden Geuenich; KOS 10 Koslar; LIM Limburg-Greifenberg; MAAS Maastricht-Vogelzang; MAIN Maintal-Hochstadt; SOEST Soest Altstadt; SPIE Spiere de Hel

temperatures as it needs July temperatures ≥ 16°[113]. This might be connected with the second climatic decline in later Michelsberg (Fig. 10). *Hedera* disappears in the middle Subboreal, probably due to sinking winter temperatures. It requires a ≥ -1,5/-2° January temperature[114]. The same holds true for *Ilex*.

The applicability of these palaeoclimatic data for the archaeobotanical interpretation of Michelsberg agriculture is difficult. For example, for cereal growing the time and the amount of precipitation in spring and summer, and the temperatures at the beginning and end of the vegetation period, as well as during the harvest period, are decisive for the yields achievable, while long lasting snow cover is disadvantageous for animal breeding[115].

To understand the modern climatic potential of the landscapes concerned, the 33 Michelsberg sites were plotted on maps with the contemporaneous average temperature and precipitation. The sites are situated today in the zone of predominantly 9–10 degrees average temperature per year and of predominantly 600–800 mm annual precipitation[116] (Fig. 11 a and b). We can state that all Michelsberg sites investigated archaeobotanically are situated today in loess landscapes with a favourable climate, well suited for agriculture.

In case of global climatic deterioration in the 5th and 4th millenium BC, the climate would still have been better in the Michelsberg area than in the northern Alpine foreland, where the earliest Egolzwil farmers and their successors continued growing naked wheat – as a winter cereal –, as well as flax and poppy. Therefore the reduction in crop species grown by the Michelsberg farmers probably points to cultural decisions that were not enforced by climatic changes. As for the growing characteristics of the crops, tetraploid naked wheat, emmer and barley might have been grown as summer crops, as the pulses certainly were. Einkorn can be grown as summer or winter cereal. Possibly the Michelsberg growing strategy with its reduced crop spectrum was based on summer crop growing due to more emphasis on stock breeding (see below).

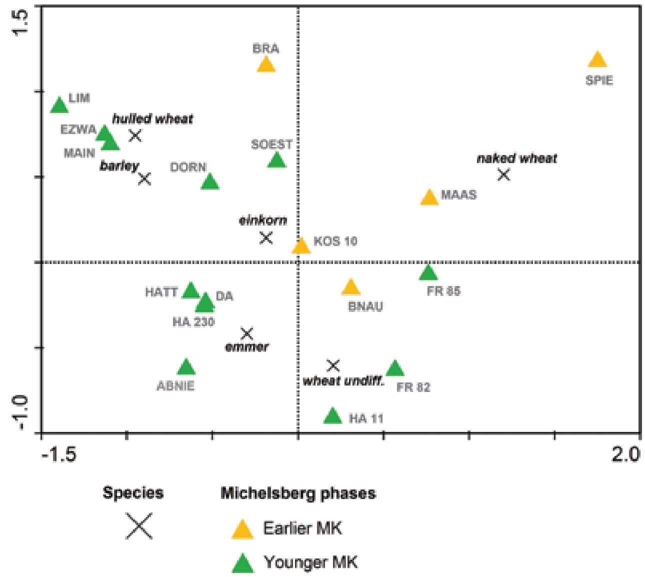

Fig. 9: Biplot with sites and cereal taxa based on a correspondence analysis of the number of seeds per cereal taxon and per site (minimum number of ten cereal seeds per site). Sites are labelled by archaeological dating to Earlier or to Younger Michelsberg (see Tab. 2)

A sudden general increase in the amount of wild plants of certain nutritional value collected could be interpreted as a reaction to some sort of crisis in the supply with food products, induced for example by climate deterioration[117]. The species most frequently found as charred finds are hazel *Corylus avellana*, apple *Malus* cf. *sylvestris* and sloe *Prunus spinosa*. As evidenced by their remains, the occurrence of edible fruits, nuts and berries of nutritional value does not increase from the Earliest Neolithic Bandkeramik to the Michelsberg period in our investigation area. Hazel *Corylus avellana* is always quite frequent at Michelsberg settlement sites, as well as before (Fig 12), but there is no difference between the individual Michelsberg phases, which could be related to known climatic changes (see above). Perhaps this question should be revised when the archaeobotanical database for the different Michelsberg phases has been improved in future.

Human impact and vegetation cover

As far as they were available, pollen diagrams from the lowlands, where the Michelsberg sites and related fields were situated, can be compared with those of the adjacent low mountain areas (Mittelgebirge) having been potential

113 See also the pollen diagram Herrenwieser See in the Black Forest (Rösch 2012): there *Viscum* is disappearing from 4200 cal BC, *Hedera* from 2700 cal. BC onwards and is again evidenced for the Medieval period.
114 Schäfer 1996, 180.
115 For the discussion see e.g. Maise 1998.
116 If compared with older climate data, for example from 1891–1930 from the "Geschichtlicher Atlas von Hessen" (1978), the landscapes are characterised by precipitation of less than100 mm on average, and higher average temperatures. Such modern climate data cannot be transferred to the prehistoric periods directly, but they provide an indication of the ecological potential of the landscapes settled by the Michelsberg farmers compared with other areas of Central Europe.

117 As argued e.g. by Arbogast *et al.* 2006; Schibler *et al.* 1997.

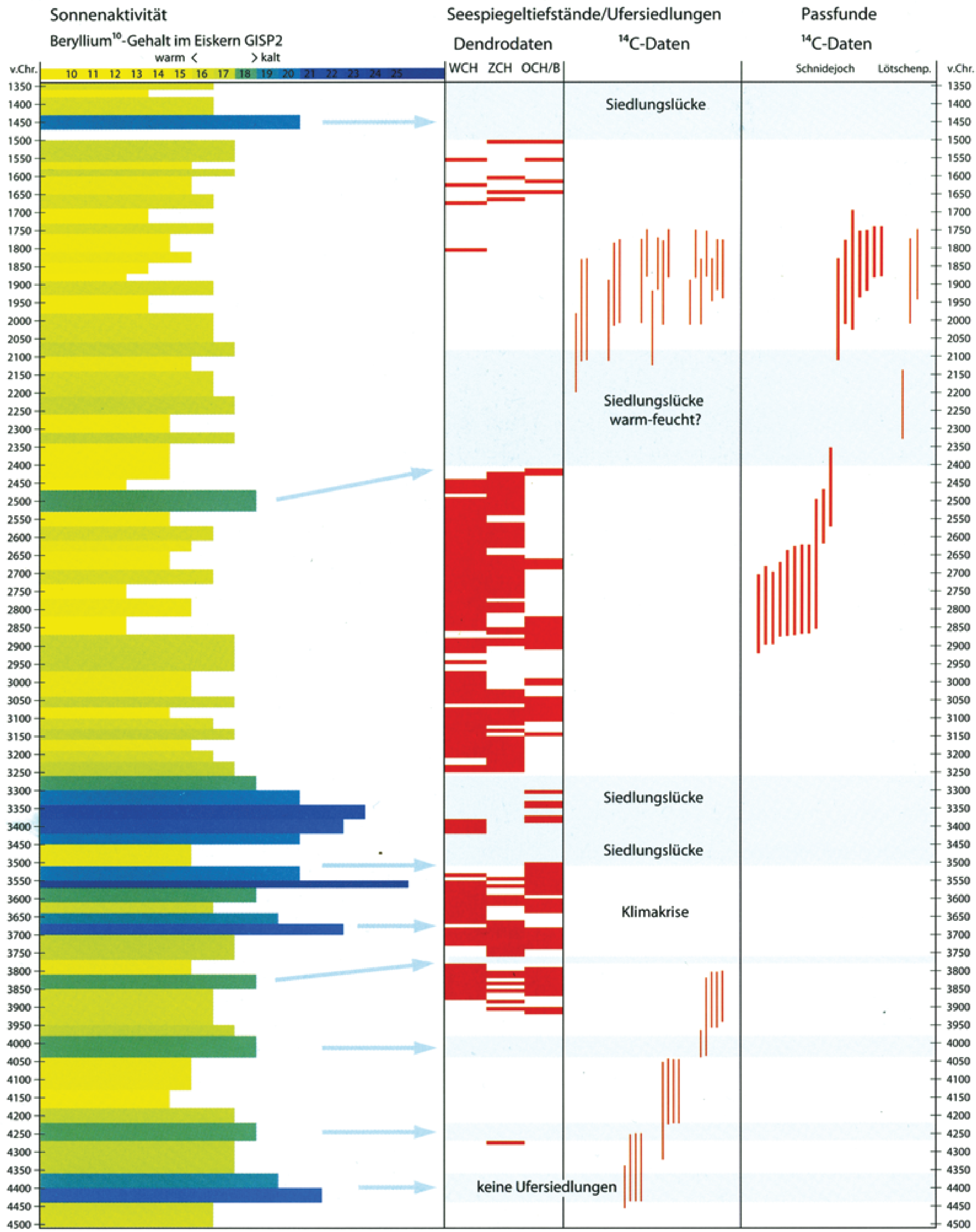

Fig. 10: Reconstruction of the climate between 4500 and 1350 BC. To the left: intensity of solar insolation based on the ^{10}BE-content from the Greenland icecore GISP. Middle: sea levels of the lakeshore sites from Swizzerland and the region of Lake Constance based on ^{14}C- and dendrochronologically dated settlement phases. To the right: ^{14}C-dated (1-sigma) finds from the Schnidejoch (thicker line) and the Lötschenpass (thin line; from Seidel 2012, Fig. 10, following Suter *et al.* 2005)

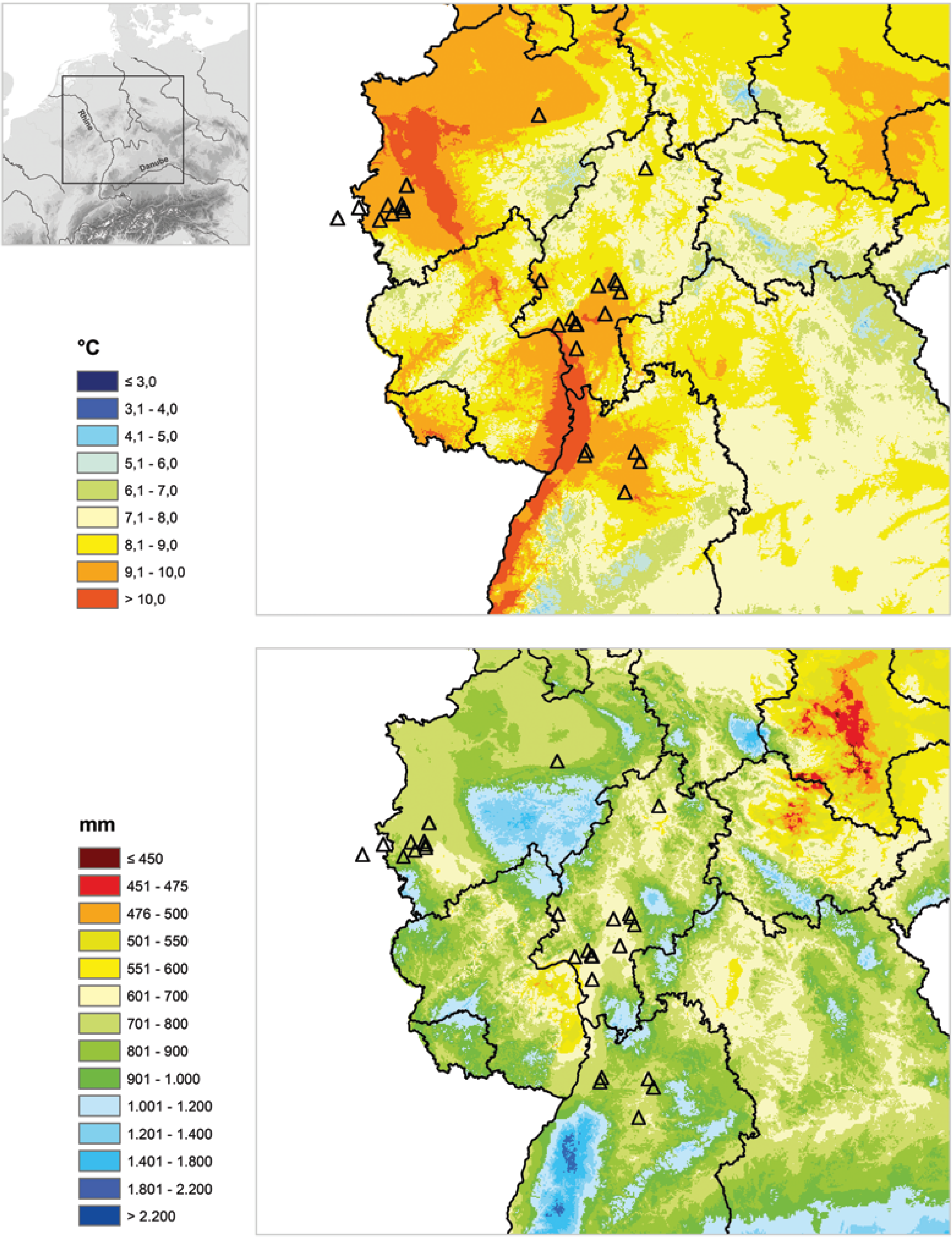

Fig. 11: Maps with ***a*** mean annual temperature (°C) and ***b*** mean annual precipitation (mm), both 1961–1990 in Germany. The Michelsberg sites investigated archaeobotanically are located in areas with a mean annual precipitation between 600 and 800 mm and a mean annual temperature of 9–10°C (except ABNIE Altenburg-Niedenstein 7,1–8°C). Maps kindly provided by the German Weather Service (Deutscher Wetterdienst DWD, Offenbach)

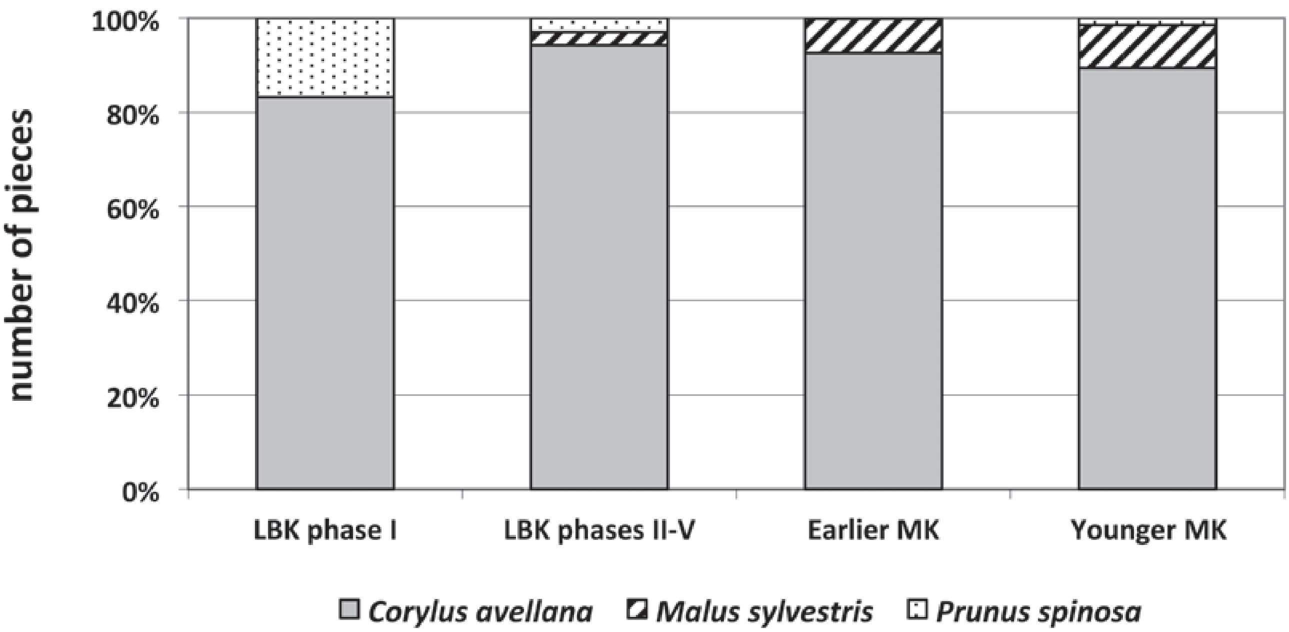

Fig. 12: Comparison of the percentages of charred plant remains of hazel *Corylus avellana*, apple *Malus sylvestris* and sloe *Prunus spinosa* for different archaeological phases of the Michelsberg culture (MK) and the Bandkeramik culture (LBK). The sample volumes analysed range from 556 litres (Earlier MK) and 3.899 l (Later MK) to 10.095 l (LBK phases II–V) and 18.392 l (LBK I), which is important for the interpretation (LBK data from the *ArboDat* database Wiesbaden)

zones of transhumance during the vegetation period. Dependant on the diameter of the deposits, their surrounding terrain and the distance to human activities, the available pollen diagrams do not show the same vegetation development. On the other hand, we can observe certain comparable supraregional phenomena.

The woodland in the distribution area of the Michelsberg settlements of the lowlands was still without hornbeam *Carpinus betulus* and beech *Fagus sylvatica* probably was slowly advancing in the South[118]. The most debated supraregional vegetation phenomenon of the centuries around 4000 BC/5000 BP involves the elm decline and related changes[119]. If we compare data from the lowlands with those of the lower mountain range, the elm pollen types and some other pollen taxa that were determined might not represent the same species with the same ecological behaviour, which complicates the discussion. In addition, due to the problems in calibration of the ^{14}C-datings (plateaus etc.) even in one and the same landscape it is difficult to decide if the elm decline in two diagrams happened at the same time or not. There is a variation of datings from about 5200 until 4900 BP[120].

The elm decline regularly occurs synchronously to an increase of the percentages of hazel and oak pollen type. Therefore it is rather unlikely that the elm decline happened in connection with climatic deterioration. A pathogen attack could have played a major role as recently discussed again by Nielsen *et al.* for northern Central Europe[121]. Selective use of elm for leaf fodder seems to be less likely as a cause, as lots of other tree or shrub species are suited for this purpose too[122].

For example, in the pollen diagrams from the Vogelsberg lower mountain area in Hesse, adjacent to the Wetterau loess landscape settled by Michelsberg farmers, the elm decline is clearly visible and is connected with an increase in *Corylus* and anthropogenic indicators, as well as pollen types such as *Plantago lanceolata* (e.g. site “Forellenteiche”, 713 m a.s.l., ca. 0,24 ha)[123]. A slight charcoal peak is also visible. Single Cerealia-type, *Picea* and *Abies* pollen grains that appear are probably the result

118 Pollen diagrams comprising this period are lacking in the lowlands of the southern distribution area of the Michelsberg culture.

119 E.g. Kalis 2010, 37 f.; Kubitz 2000; Rösch 2012; Schäfer 1996, 175; further references there.

120 E.g. Herbig/Sirocko 2012; Rösch 2012; Schäfer 1996, 175; further references there.

121 Nielsen *et al.* 2012 (further references there), 143; see also the discussion in e.g. Kubitz 2000, 67 ff.; Schäfer 1996, 175 ff.

122 E.g. Haas/Rasmussen 1993; Rackham 2003; Vera 2002; more references there.

123 Schäfer 1996, 175 ff.

of long distance transport. This pollen assemblage can be interpreted as a sign of an opening up of the forest, maybe by burning, which encouraged undergrowth and therefore wood pasture and the availability of gathered plants. A further indicator for wood pasture is the occurrence of *Pteridium*, a "pasture weed" which is avoided by the animals[124]. The growth of *Pteridum* is encouraged by burning too.

Another Vogelsberg diagram, "Breungesheiner Heide", comes from to a raised bog (715 m a.s.l., ca. 5 ha[125]). Due to its size it is more regionally influenced. Here too the elm decline is visible and combined with an increase of anthropogenic indicators, etc. Similar phenomena are found in other mountain regions, for example the Black Forest (diagram Herrenwieser See, 840 m a.s.l., 1,2 ha) or the Eifel region[126]. The *Plantago lanceolata* curve is not always closed, which might be connected with the number of pollen counted per sample or the distance to – possibly pastoral – activities (see below)[127].

Plantago lanceolata is present in the vegetation of the investigation area at least from the Mesolithic or early Holocene[128]. It occurs sometimes on-site as charred seeds in settlement samples from the Bandkeramik onwards, but it is very rare[129]. If it had been a weed current in the fields or fallows, it should occur regularly with the crop remains as for example *Bromus*, *Chenopodium* or *Polygonum* species do. As this is not the case during the Neolithic this pollen-type most likely can be interpreted as an indicator for pasture there. Important for this interpretation is the occurrence of the elm decline and related phenomena even in pollen diagrams of deposits far from Neolithic settlements, such as all the diagrams of the lower mountain range, especially those with small diameter and therefore stronger local (/extralocal) impact. This also makes it unlikely the elm decline having been connected with arable activities. Instead, the coincidence of the elm decline and the increase of shrubs and trees that require light, and the beginning of a more or less closed *Plantago lanceolata* curve combined with the occurrence of other signals (*Pteridium*, *Taxus*, *Corylus, Salix, Populus*, Poaceae, micro-charcaol usw.), could be linked with a significant increase in widespread wood pasture. This might have been connected with burning activities by the herdsmen to encourage undergrowth and likewise fodder supply for the animals as indicated e.g. by micro-charcoal and *Pteridium* pollen type. Unfortunately it is not possible to check this systematically at present, as micro-charcoal has seldom been counted for the pollen diagrams in the Michelsberg distribution area of the loess landscapes[130]. In addition, the deposit of micro-charcoal might have different causes in the mountain area compared with the lowlands (see next chapter).

Another indication for an opening up of the landscapes is an increase in the occurrence of *Malus sylvestris* as plant macro-remains over time (Fig. 12). This might be explained as the result of an increase in open stands suited for crab apple trees, which require light, to grow. Further indications of an opening up of the landscapes are provided by the archaeozoological results (see below).

Burning the fields?

Strikingly, in general charred wild plant species, representing potential field weeds, are extremely rare among the archaeobotanical finds from Michelsberg sites (Fig. 13 and Tab. 4). This result has to be explained, and it connects the Michelsberg culture not only with the farmers of the Alpine foreland but also with the Funnelbeaker culture in the north[131] and with the Neolithic archaeobotanical data from Great Britain and Ireland[132].

Schier[133] suggests the delayed ("tertiary") introduction of the Neolithic subsistence into the Alpine foreland and to northern Central Europe as a consequence of the delayed introduction of the "slash and burn" cultivation method, which might have been necessary to get satisfying yields on the qualitatively worse soils there. The "disadvantage" of this method is the demand for land and labour – as the field areas are shifted regularly and the abandoned areas are wooded quickly again from the wood trunks and roots remaining in the fields, with the resulting necessity to cut the woodland again and again every maybe ten or more years[134].

124 E.g. Schäfer 1996, 181 ff.
125 Schäfer 1996.
126 Kalis/Meurers-Balke 1997, 41 ff.; Kühl/Moschen 2012; Litt *et al.* 2009; Rösch 2012.
127 For the methodological discussion see e.g. Hellman *et al.* 2009.
128 Evidence e.g. from pollen diagrams by Knörzer/Meurers-Balke 1999, 123.
129 Knörzer 1997; Kreuz 2010/2012; Willerding 1986, 186 ff.
130 See also the discussion in Kreuz 2010/2012, 57 ff. and 112 ff.
131 See the archaeobotanical data compilation in Kirleis *et al.* 2012, 225.
132 ABCD database state 2013, see *http://intarch.ac.uk/journal/issue1/tomlinson_toc.html*; personal comm. July 2013 and internal reports kindly provided by Angela Monckton (Univ. Leicester) and Ruth Pelling (English Heritage, Portsmouth); see also Jones/Rowley-Conwy 2007; McClatchie *et al.* 2013; Moffett *et al.* 1989.
133 Schier 2009.
134 E.g. Rösch *et al.* 2011; critically: Hosch/Jacomet 2004, 128 ff.; Maier 1999.

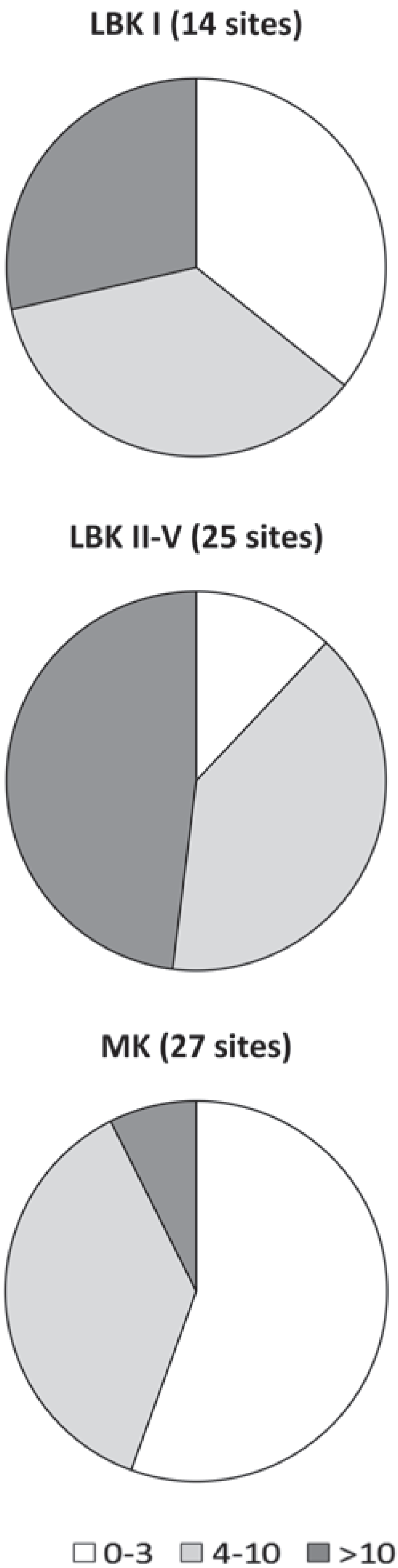

Fig. 13: Number of potential weed taxa from Michelsberg sites compared with Earliest Bandkeramik (LBK I) and Younger Bandkeramik data (LBK II–V). Included are the Ecological Groups 1–4, 6 and 7 (for the Ecological Groups used see Tab. 4 as well as Kreuz 2004/2005, 122 Tab. 8 and 147 ff.). Michelsberg sites predominantly have lower numbers of weed taxa

At the moment, there is no evidence making likely a serious degradation of the Loess soils during the time of the Michelsberg culture, which would provide the basis for the necessity of such a field management there. On the other hand one aspect of this method is worth considering, which might have been useful for the Michelsberg farmers in the loess landscapes too: As revealed by the results of the Forchtenberg experiments, the technique of preparing the field area with a fire roll before sowing the seed (Fig. 14) reduces the amount of weeds in the first year considerably[135]. In addition fire, in any case, promotes the suppression of pests and diseases. Such a management of the fields might be a possible explanation for the phenomenon of low densities of weed seeds and weed species at Michelsberg sites, compared with Bandkeramik assemblages (Fig. 13). High resolution pollen diagrams with micro-charcoal counts within or adjacent to the loess landscapes settled by the Michelsberg farmers are urgently needed, to discuss such a cultivation method. Actually, regular burning of the stubble fields has been a traditional and widespread praxis, e.g. in Germany until the seventies, which then – alleged due to the fire risk for nearby villages and buildings – has been forbidden by law and replaced by the management of herbicides and insecticides.

Wild and domestic animals

Cattle *Bos primigenius taurus*, pig *Sus scrofa domestica*, sheep *Ovis orientalis aries*, goat *Capra aegagrus hircus* and dog *Canis lupus familiaris* are the domestic animals regularly found at Michelsberg sites where bones are preserved and determined. However, bones are not preserved at all in the whole Lower Rhine area, for example, due to higher precipitation and therefore stronger decalcification of the soil. That is why it is not possible to prove at present whether regional variations in Michelsberg stock farming existed or not.

Cattle is often, but not always, the dominating species among domestic animals, followed by pig, sheep/goat and dog. Where it can be determined, remarkably more sheep occur than goat at the Michelsberg sites[136].

135 Ehrmann/Rösch 2005; Schier 2009, 23 ff.; see also the discussion in Eckmeier *et al.* 2007.

136 E.g. Arbogast 1998, Fig. 3; Benecke/Wotzka 1998, 92; Beyer 1972; Höltkemeier/Fetsch in prep.; Knoche 2013c, 192 ff.; Kokabi 2008 a and b; Schlenker 2008; Stephan 2008a and b; Steppan 1998; 2003; 2007; 2010; Vanmontfort 2004; Vanmontfort *et al.* 2001/2002, 59.

Fig. 14: Burning the fields, as demonstrated at the experimental cereal growing site Forchtenberg (Baden-Württemberg/Germany), not only manures the soil but also reduces pests, diseases and weeds (photo Angela Kreuz 13. 6. 2012)

Horse has been discussed as an innovative element of Michelsberg stock farming[137]. The state of research does not allow at the moment to decide if the bone finds are from domestic horse *Equus caballus* or from wild horse *Equus ferus* due to the difficulties of morphometric determinations. Apparently the amount of horse finds increases in southwest and southern Germany during the Late Neolithic. There are more horse finds at Michelsberg sites than for example in Bandkeramik ones, which is discussed as the result of influences from the Pfyn-Altheim group of Upper Swabia (Oberschwaben)[138].

Horses, like cattle and sheep, are (and probably were) so-called grazers, as they favour predominantly grass as fodder[139]. Therefore an increase in wild horse finds indicates an increased opening of the woodland, which allowed more grasses requiring light to grow. Other wild animal finds point in the same direction, for example hare, or beavers which – under "natural" conditions – create extended meadows in the river valleys. It is quite possible, that the increase of horse finds is related to an increase in the availability of horse as kill due to an opening up of the woodland by burning and wood pasture[140] as part of the Middle Neolithic, and especially of the Late Neolithic, farming systems.

137 E.g. Benecke/Wotzka 1998, 92; Grefen-Peters, cited in Geschwinde/Raetzel-Fabian 2009, 265 ff.; Herrmann/Jockenhövel 1990, 160; Steppan 2007.

138 Benecke/Wotzka 1998, 834; Benecke 2002; Stephan 2008a, 235 ff.

139 E.g. Vera 2002; discussion in Kreuz 2008, 2010/2012.

140 Kreuz 2010/2012, 73; more references there.

Final remarks

Michelsberg daily life is difficult to comprehend, as the remains are so patchy. The archaeobiological and archaeological state of research is not sufficient to arrive at a final hypothesis, but it allows confirmation of some old and formulation of some new ideas, as well as some research desiderata for the future.

Compared with previous and contemporaneous neighbouring cultures, Michelsberg farmers grew a reduced crop spectrum, probably without cultivation of oil-/fibre plants. As there is very little evidence for pulses, emphasis was obviously placed on cereal cultivation. Like the small amount of weed species found, this fact connects Michelsberg agriculture with the Funnelbeaker culture and the Early Neolithic of Great Britain and Ireland[141]. The naked wheat grown seems to have been of the tetraploid form, which was probably adopted from the previous Bischheim culture. Due to the state of research, the introduction of tetraploid naked wheat to the Bischheim and Michelsberg distribution areas still needs further investigation. Both archaeological cultures have strong stylistic affinities to the French Chasséen (see above).

On question is, what replaced flax and poppy and why? As for flax *Linum usitatissimum* as a fibre plant, one explanation worth considering might be the occurrence of the wool-sheep, not to forget the possibility of the wool-pig already in the Late Neolithic. This is of course difficult to proof in view of the rarity of archaeological finds as a result of the problems of (organic) preservation[142]. The find of the zoomorphic figurine of a ram from Jordansmühl (Jordanów Śląski, Poland) has also been discussed in this context. It is contemporary with younger Michelsberg and is interpreted as wearing a "fleece"[143].

On the other hand, flax is a time consuming and demanding crop plant. Within the Michelsberg distribution area diverse other natural fibres were available, like nettle *Urtica*, the bast of trees etc., which might also have been used too, as is suggested for example by the manifold ethnographic evidence for such crafts[144]. As for poppy and flax as crop plants providing oil or fat, evidence for the Neolithic use of wild oil-plants like (apart from hazel nut) *Brassica campestris*, *Descurainia sophia* and *Camelina sativa* var. *microcarpa* was presented by Maier, Schlichtherle and Villaret-von Rochow[145]. Jacomet *et al.*[146] discuss the possible substitution of oil crop plants by animal fat in general.

The current state of research – although just pieces of a puzzle – seems to confirm an old hypothesis about Michelsberg subsistence: palynological and archaeozoological data are indicating a certain opening up of the forest canopy. This might be connected with an increased emphasis on pasture economy. The latter would explain the reduced crop spectrum compared to the Bischheim culture, as well as compared with the contemporaneous cultures of the lakeshore sites in the northern Alpine foreland.

In this context the inspiring "Braunschweiger Modell", hypothesized by Geschwinde and Raetzel-Fabian must be mentioned[147]. It favours the model of a society comprising two groups of people: sedentary farmers on one hand, and itinerating herdsmen practising transhumance with large flocks on the other, both groups returning to the enclosures for seasonal communal feasting and related social and religious activities[148]. The alternative of the use of the enclosures as simple domestic animal fences (Viehkrale) is quite unlikely, because – from experience – herds can be easily controlled with a few well trained shepherd dogs[149]. In any case, such big constructions are not necessary for fencing in domestic animals.

The function of the Michelsberg causewayed enclosures is still under discussion. There is no doubt that they represent a cooperative, communal performance as "large working parties had to cooperate for a considerable amount of time"[150]. It cannot be ruled out that at the time of their construction the remains of the rarer earlier Neolithic earthworks were still "visible remains of 'ancestral' occupations in the landscape"[151]. Following Jeunesse and Seidel, the construction of the earthworks and the deposition of deer heads, aurochs horns, sometimes whole vessels, human bones or skeletons and parts of animal carcasses are evidence for the practice of rituals[152]. In many cases several ditches have been dug one after the other instead of repairing the first one. Müller[153] therefore also discusses ritual centres as one potential function of earthworks. Seidel[154] argues in a similar way by comparing the numbers of enclosures and open settlements in the region of Middle Neckar and Kraichgau, Baden-Württemberg. The ratio of 12 earthworks to 78 unfortified settlements led her to assume earthworks as places for activities sustaining social cohesion, such as rituals, feasts or markets. The same holds true for the Scheldt basin, Belgium, where 68 Michelsberg unfortified sites (settlements?) and 14 enclosure sites reflect the state of research[155]. In any case, these

141 For the archaeobotanical data see footnote 134 and Kirleis *et al.* 2012, McClatchie *et al.* 2013).

142 E.g. Preuß 1998, 86, 120.

143 Picture of the idol recently published in Siebenmorgen/Lichter 2010, 22.

144 Just as examples: Ertug-Yaras 1997; Godwin 1970; Meligren 2012; Kunst- und Ausstellungshalle Bonn 2013.

145 Maier 2011, 98 ff.; Schlichtherle 1981; Villaret-von Rochow 1967.

146 Jacomet *et al.* 1989, 207.

147 Geschwinde/Raetzel-Fabian 2009, e.g. 253.

148 See also the discussion in Knoche 2013c, 190 ff.; Vanmontfort 2004, 331 as well as the comments by Müller 2011; Furholt and Müller 2011 about "ritual cooperation", "ritual collectivity" and earthworks as an expression of cultural identity.

149 Kreuz 2010/2012, chapter 8, more references there.

150 De Grooth 1991, 174 f.; see also Vermeersch/Burnez-Lanotte 1998, 51.

151 Vanmontfort 2004, 311.

152 Jeunesse 2010, 55; Jeunesse/Seidel 2010, 63 ff.

153 Müller 2010, 255 ff.

154 Seidel 2010, 87.

155 Vanmontfort 2004, 314.

enclosures “must also have created and enforced a sense of group identity” within the Michelsberg distribution area[156].

In future, large-scale excavations in suitable site types and features, accompanied by systematic archaeobiological investigations and more absolute datings are needed in order to advance research on the Michelsberg culture. And last but not least, archaeobotanical data from the French Michelsberg settlement sites, as well as from the French Chasséen and St. Uze complex and subsequent archaeological cultures, could contribute to a better understanding of the western Central European Late Neolithic and its southern connections.

Acknowledgments

Many thanks to Örni Akeret, Ferran Antolin, Corrie Bakels, Laurent Bouby, Christoph Brombacher, Deutscher Wetterdienst Offenbach, Thomas Doppler, Renate Ebersbach, Sandra Fetsch, Detlef Gronenborn, Eda Gross, Monika Hellmund, Stefanie Jacomet, Benedikt Knoche, Sabine Kuhlmann, Uschi Maier, Meriel McClatchie, Angela Monckton, Ruth Pelling, Birgit Regner-Kamlah, Wolfram Schier, Helmut Schlichtherle, Aurélie Salavert, Ute Seidel, Hans-Peter Stika, Bart Vanmontfort, Nicola Whitehouse and Samuel van Willingen for useful informations, to the German Research Association DFG for funding, to David Wigg-Wolf for improving the English and to Julian Wiethold as referee for useful remarks.

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Tab. 1 a und b: General information on the Michelsberg sites investigated archaeobotanically: archaeobotanical project-number and/or abbreviation of the site name; name of city or place; site type; archaeological phase(s) (*MK* Michelsberg culture); feature types: *Gr* pit, *GrKo* pit complex, *GraWe* ditch system (larger enclosure), *Silo* silo/storage pit, *Gra* ditch, *Her* hearth/fireplace, *Of* oven, *Pfo* posthole, *SchlGr* V-shaped pit, *Kult* culture layer; *Wal* rampart/earthwork/fortification; natural geographic unit; altitude (a.s.l. metres above sea level); mean annual temperature (°C); mean annual precipitation (mm); longitude/latitude; excavating institution; archaeologist responsible; excavator responsible; archaeobotanist responsible. The results from Bazoches, Cuiry-lès-Chaudardes, Heerlen-Schelsberg and Maastricht-Klinkers could not be included in the calculations as the data are too few or not fully available. The data from Heilbronn-Klingenberg had to be excluded, because the plant remains are partly mixed with material from the earlier Bandkeramik colonization.
The archaeobotanical data are differentiated into "Earlier Michelsberg" (MK I and/or II) and "Younger Michelsberg" (one or several phases of MK III–V) and "Michelsberg undifferentiated" (MK II/III included in this group)

Project-No.	Abbr. site	Site	Archaeol. Phases	Site type	Feature types	Geographic unit	a.s.l (m)	Temp. °C	Precip. (mm)	Longitude	Latitude	Excavation by	Resp. archaeologist	Resp. excavation	archaeobotanist
Belgium															
Spiere	SPIE	Spiere de Hel	MK I/II	enclosure	Gra					3,359947	50,720148		B. Vanmontfort		C. Bakels/F. Damblon
Netherlands															
Maa-Vo	MAAS	Maastricht-Vogelzang	MK I/II	channel border	Kult	Meuse valley	50			5,714938	50,825675	Archäologie, Uni Leiden	F. Bruonen/ L. Kooijmans	Archäologie/Uni Leiden	C. Bakels
Northrhine – Westfalia															
FR 82	FR 82	Jüchen-Garzweiler, Elfgen	MK III-V	settlement	Gr	Jülicher Börde	85	9,1–10	701–800	6,528755	51,078372	LVR Archäologie	S.-K. Arora	W. Schwellnus	K.-H. Knörzer/T. Zerl
FR 85	FR 85	Jüchen-Garzweiler, Belmen	MK III-V	settlement	Gr	Jülicher Börde	90	9,1–10	701–800	6,524464	51,077492	LVR Archäologie, Außenstelle Titz	S.-K. Arora	S.-K. Arora	K.-H. Knörzer/T. Zerl
HA 11	HA 11	Hambach-Niederzier	MK III-V	settlement	Gr	Zülpicher Börde	115	9,1–10	701–800	6,482532	50,887105	LVR Archäologie, Außenstelle Titz	unbearbeitet	S.-K. Arora	K.-H. Knörzer/T. Zerl
HA 32	HA 32	Hambach-Niederzier	MK III-V	enclosure	Gr, GraWe	Zülpicher Börde	95	9,1–10	701–800	6,465946	50,933916	LVR Archäologie	unbearbeitet	W. Schwellnus	K.-H. Knörzer/Tanja Zerl
HA 230	HA 230	Hambach	MK III-V	settlement	Gr	Zülpicher Börde	100	9,1–10	701–800	6,485636	50,912262	LVR Archäologie	unbearbeitet	W. Schwellnus	K.-H. Knörzer
Inden 9	IND 9	Inden Geuenich	MK undiff.	enclosure	GraWe	Jülicher Börde	115	9,1–10	701–800	6,354472	50,865990	SAP (LVR, Außenstelle Titz)	B. Höhn/B. Päffgen	W. Schwellnus (1973/74)/B. Päffgen (2004)	K.-H. Knörzer (1973/74)/T. Zerl (2004)
Koslar 10	KOS 10	Koslar	MK I/II	enclosure	Gr, GrKo	Jülicher Börde	93	9,1–10	701–800	6,305161	50,928155	SAP (LVR)	J. Eckert/S. Schamuhn	J. Eckert (SAP)	K.-H. Knörzer/T. Zerl
Soest Alts	SOEST	Soest	MK III-V	enclosure	Gr, GraWe	Hellwegbörden	90	9,1–10	701–800	8,092259	51,569669	Stadtarchäologie Soest	B. Knoche	B. Knoche	W.-D. Becker/J. Meurers-Balke/S. Schamuhn
T&R Aachen	TR	Aachen	MK undiff.	enclosure	Gr, Pfo	Jülicher Börde	206	9,1–10	801–900	6,209360	50,816001	ArcheoNet	M. Aiessen	M. Aiessen	T. Zerl/S. Schamuhn
Hesse															
AK4	EZWA	Echzell "Wannkopf"	MK V	hillfort	Gr, Her, Pfo	Wetterau	254	8,1–9,0	601–700	8,946896	50,395039	Uni Frankfurt	B. Höhn/S. Fetsch	B. Höhn	A. Kreuz/J. Wiethold
AK10	ABNIE	Altenburg, Niedenstein	MK II?-IV	hillfort	Gr	Westhessische Senke	475	7,1–8	701–800	9,321071	51,235553	KAL	U. Söder/M. Meyer/ S. Fetsch	U. Söder/M. Meyer	A. Kreuz
AK42	DA	Dauernheim, Ranstadt	MK III-V	hillfort	Gr, Gra, GraWe, Pfo	Wetterau	199	9,1–10	601–700	8,966602	50,370773	Uni Frankfurt	B. Höhn/H.-P. Wotzka/S. Fetsch	B. Höhn/H.-P. Wotzka	N. Boenke/A. Kreuz
AK95	ERB	Erbenheim, Wiesbaden	MK III-IV?	settlement	Gr	Main-Taunus-Vorland	150	9,1–10	601–700	8,277512	50,056598	LfDH	E. Pachali	E. Pachali	A. Kreuz
AK166	DORN	Dornheim, Groß-Gerau	MK III-V	settlement	Gr	Bergstraße	88	9,1–10	601–700	8,486656	49,882413	Uni Frankfurt	J. Lüning/S. Fetsch	J. Lüning	A. Kreuz/J. Wiethold
AK276	BNAU	Bad Nauheim	MK II (?-IIIa)	enclosure	Gr, Gra, GrKo, Pfo	Wetterau	149	8,1–9,0	601–700	8,753540	50,353841	LfDH	S. Fetsch	N. Boenke	A. Kreuz
AK280	HATT	Hattersheim	MK III-V	settlement	Gr	Main-Taunus-Vorland	107	9,1–10	601–700	8,476559	50,067079	LfDH	U. Recker/K. M. Schmitt/S. Fetsch	K. M. Schmitt	A. Kreuz
AK281	KAP	Kapellenberg, Hofheim	MK (?II) III-V	hillfort	Gr, Pfo, Schi, Wal	Main-Taunus-Vorland	292	9,1–10	601–700	8,437281	50,105393	RGZM	D. Gronenborn/N. Richter/S. Fetsch	N. Richter/B. Hüner-fauth/M. Wagner	A. Kreuz
AK312	GLAUV	Glauberg – Vorwall	MK (?II) III-V?	hillfort	Gr	Ronneburger Hügelland	200	9,1–10	701–800	9,008479	50,311444	RGZM	S. Fetsch/D. Gronen-born	S. Fetsch/D. Gronenborn	A. Kreuz
AK320	HATT	Hattersheim	MK ?III-V	settlement	Gr, GrKo, Silo	Main-Taunus-Vorland	97	9,1–10	601–700	8,492592	50,063231	LfDH	U. Recker/J. Meyer/ S. Fetsch	J. Meyer	A. Kreuz
AK322	LIM	Limburg-Greifenberg	MK (?II) III/ IV(?V)	hillfort	Gr, Gra, Pfo, SchlGr, Silo	Limburger Becken	180	9,1–10	601–700	8,078409	50,385143	RGZM/LfDH	S. Fetsch/D. Gronen-born	S. Schade-Lindig, S. Fetsch/D. Gronenborn	A. Kreuz
AK331	MAIN	Maintal-Hochstadt	MK III-V	settlement	Gr, GrKo, Of	Untermainebene	100	9,1–10	601–700	8,826942	50,145456	Uni Hamburg	G. Schwitalla/ B. Ramminger	B. Ramminger	A. Kreuz

Project-No.	Abbr. site	Site	Archaeol. Phases	Site type	Feature types	Geographic unit	a.s.l (m)	Temp. °C	Precip. (mm)	Longitude	Latitude	Excavation by	Resp. archaeologist	Resp. excavation	archaeobotanist
Baden-Württemberg															
BRA	BRA	Bruchsal, Aue	all	enclosure	Gr, Gra, KöGrab, SchlGr	Kraichgau	114	9,1–10	701–800	8,587946	49,123457	LAD Ba-Wü	R.-H. Behrends/S. Reiter/B. Regner-Kamlah	R.-H. Behrends	M. Rösch
ILS	ILSFE	Ilsfeld, Ebene	MK undiff.	enclosure	Gr	Neckarbecken	284	9,1–10	801–900	9,215112	49,051157	LAD Ba-Wü; Hist. Museum Heilbronn	U. Seidel	J.Biel/H.Zürn LAD BaWü R. Koch Hist. Mus.HN	U. Piening
LBH	LBH	Leonberg-Höfingen	MK undiff.	settlement	Gr	Neckarbecken	365	9,1–10	701–800	9,030283	48,817108	LAD Ba-Wü; Arbeitskreis VFG Leonberg	U. Seidel	E. & I. Bernt/E. DeGennaro/B. Volkmer/U. Seidel	U. Maier
MIU	MIU	Michaelsberg/ Untergrombach	MK III-V	enclosure	Gra	Kraichgau	265	9,1–10	701–800	8,566194	49,088398	LAD Ba-Wü; Bad. Landesmuseum	K. Schumacher/A. Bonnet/A. Dauber/J. Lüning/M. Heumüller	K. Schumacher/A. Bonnet/A. Dauber/W. Bauer/M. Heumüller	M. Rösch
further sites mentioned in the text															
France															
BAZ	BAZ	Bazoches/Aisne	MK	enclosure		Aisne valley				3,619562	49,306851	Uni. Paris I, CNRS			C. Bakels
Cu	CU	Cuiry-lès-Chaudardes	MK	settlement? (2 silo pits)		Aisne valley				3,772807	49,385399	Uni. Paris I, CNRS			C. Bakels
Netherlands															
HeS	HeS	Heerlen-Schelsberg		enclosure		Meuse valley				5,966084	50,906803	Uni. Leiden			C. Bakels
		Maastricht-Klinkers	MK III	settlement		Meuse valley	62					Uni. Leiden	Schreurs		C. Bakels
Baden-Württemberg															
HKB	HKB	Heilbronn-Klingen-berg	(LBK) MK	hillfort		Kraichgau	123	9,1–10	601–700	9,155126	49,117793	LAD Ba-Wü	J. Biel	J. Biel	H.-P. Stika

Tab. 2: Database of the 27 Michelsberg sites included in the quantitative evaluations (*PCodes* plant codes). Sample volumes are not available at three sites: at Bruchsal and Spiere volumes are partly, at Ilsfeld completely lacking, and so have been (partly) excluded from the calculation of the concentrations

Project	Abbr.	Site name	Archaeological dating	Features	Samples	Sample volume (l)	Plant remains (without wood)	Number of taxa (Pcodes)
AK276	BNAU	Bad Nauheim	Earlier MK	6	14	125,5	5.998	16
BRA	BRA	Bruchsal	Earlier MK	2	35	> 5,34	121	19
Koslar 10	KOS 10	Koslar	Earlier MK	24	95	216,95	2.465	22
Maa-Vo	MAAS	Maastricht, Vogelzang	Earlier MK	1	17	121	542	15
Spiere	SPIE	Spiere de Hel	Earlier MK	4	10	> 36,6	580	14
AK10	ABNIE	Altenburg, Niedenstein	Younger MK	4	26	71,62	70	11
BRA	BRA	Bruchsal	Younger MK	3	9		27	16
AK42	DA	Dauernheim, Ranstadt	Younger MK	47	187	2.523,65	18.202	69
AK166	DORN	Dornheim, Groß-Gerau	Younger MK	1	13	143,9	338	21
AK95	ERB	Erbenheim, Wiesbaden	Younger MK	1	2	0,21	24	3
AK4	EZWA	Echzell “Wannkopf”	Younger MK	10	48	417,04	353	14
FR 82	FR 82	Jüchen-Garzweiler, Elfgen	Younger MK	2	5	41,18	689	10
FR 85	FR 85	Jüchen-Garzweiler, Belmen	Younger MK	6	9	16,97	1.900	12
HA 11	HA 11	Hambach-Niederzier	Younger MK	7	26	52	276	13
HA 32	HA 32	Hambach-Niederzier	Younger MK	5	10	21,00	200	16
HA 230	HA 230	Hambach	Younger MK	4	8	9,28	106	11
AK280	HATT	Hattersheim	Younger MK	1	1	21	3	3
AK320	HATT	Hattersheim	Younger MK	10	15	115	415	24
AK322	LIM	Limburg-Greifenberg	Younger MK	37	50	458,5	66	15
AK331	MAIN	Maintal-Hochstadt	Younger MK	5	5	41	530	13
MIU	MIU	Michaelsberg/Untergrom-bach	Younger MK	1	17	85,08	31	10
Soest Alts	SOEST	Soest, Altstadt	Younger MK	5	38	212,3	175	12
BRA	BRA	Bruchsal	MK undiff.	6	91	> 25,01	377	38
AK312	GLAUV	Glauberg – Vorwall	MK undiff.	1	3	50,5	82	11
ILS	ILSFE	Ilsfeld	MK undiff.	3	3		726	2
Inden 9	IND 9	Inden Geuenich	MK undiff.	10	19	121,05	1.481	27
AK281	KAP	Kapellenberg, Hofheim	MK undiff.	12	39	158,68	10	6
LBH	LBH	Leonberg-Höfingen	MK undiff.	1	1	10	99	8
T&R Aachen	TR	Tank und Rast Aachen	MK undiff.	9	9	50,30	56	7
Sum				**228**	**805**	**5.083,71**	**35.942**	**113**

Tab. 3: Diachronic comparison of frequency values (% of occurrence per features) from oil-/fibre-plants and pulses. Despite the different numbers of features investigated it is evident, that oil plants and pulses can be preserved in a charred state if they were in use (Bandkeramik/LBK and Middle Neolithic data (Großgartach, Hinkelstein and Rössen) as well as data from younger prehistoric periods from the *ArboDat* database, Wiesbaden)

	Linum usitatissimum	*Papaver somniferum*	*Camelina sativa*	*Lens culinaris*	*Pisum sativum*	sites	features	samples	volume (l)
LBK I	21			64	57	14	229	1.007	18.393
LBK II-V	54	33		63	88	24	317	737	10.095
Middle Neolithic				33	33	12	34	199	3.439
Michelsberg				**11**	**22**	**27**	**228**	**805**	**5.151**
Bronze Age				35	10	20	48	177	1.459
Hallstatt		22	56	44	33	18	84	151	1.449
Latène	56	20	44	56	60	25	221	639	6.471
Roman	24	5	39	39	45	38	307	1.005	11.322
Sum						**178**	**1.468**	**4.720**	**57.779**

Tab. 4: Taxa list of all Michelsberg sites with number of pieces per site for each taxon. Taxa are sorted into Ecological Groups. Botanical plant names according to Flora Europaea (Tutin *et al.* 1964–1980, Consolidated Index, Cambridge University Press). Abbreviation: *Rtype* type of plant remains, *HSB* glume base, *Spi* rachis segment, *SaFr* seed/fruit, *BGF* porridge/(flat) bread/pulp, *Hano* halm node (cf. Cerealia), *Hil* hilum (Fabaceae)

Site	Rtype	Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	English name
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
1 Riparian/Floodplain vegetation																													
Mentha arvensis	Sa/Fr																								1				Corn Mint
Mentha cf. *arvensis*	Sa/Fr																								1				Corn Mint
cf. *Myosoton aquaticum*	Sa/Fr														1														Water Chickweed
Polygonum hydropiper	Sa/Fr							1																					Marsh-pepper smartweed
Polygonum cf. *hydropiper*	Sa/Fr									2																			Marsh-pepper smartweed
Polygonum lapathifolium agg.	Sa/Fr							1																					Pale smartweed
Polygonum cf. *minus*	Sa/Fr														1														Small Water-pepper
2 Grassland vegetation																													
Carex muricata agg.	Sa/Fr												1																Prickly sedge
cf. *Cerastium arvense*	Sa/Fr														1														Field Mouse-ear
Festuca/Lolium	Sa/Fr														2														Fescue/Ryegrass
Galium mollugo/ verum	Sa/Fr														1														Hedge- / Lady's Bedstraw
Lolium perenne	Sa/Fr																								1				Perennial Rye-grass
Luzula campestris/ multiflora	Sa/Fr																								7				Field- / Common Wood-Rush
Phleum pratense s.l.	Sa/Fr													5	3						1			1	1				Meadow cat's-tail
Phleum pratense/ Poa annua	Sa/Fr									1																	2		Meadow cat's-tail/ Annual meadow grass
Plantago spec.	Sa/Fr																								1				Plantain

Site		Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
Poa annua	Sa/Fr										1																		Annual Meadow-grass
Poa cf. *annua*	Sa/Fr														7														Annual Meadow-grass
Poa spec. *non annua*	Sa/Fr														1														Meadow-grass (other than annual)
Poa spec.	Sa/Fr														2										1				Meadow-grass
Polygonum aviculare agg.	Sa/Fr														1							5			10				Knotweed
Rumex acetosella agg.	Sa/Fr																								1				Sheep's Sorrel
Trifolium pratense s.l.	Sa/Fr	1																											Red clover
Trifolium cf. *pratense* s.l.	Sa/Fr														2														Red clover
Trifolium spec.	Sa/Fr									1																			Clover
3 Ruderal vegetation																													
Bromus sterilis/tectorum	Sa/Fr																2												Sterile brome/Cheatgrass
Galium cf. *aparine*	Sa/Fr	3									1		12		47		1							1					Cleavers goose-grass
Hyoscyamus niger	Sa/Fr						1								3										1				Henbane
Lapsana communis	Sa/Fr	2								2	2		1		5														Nipplewort
Sambucus ebulus	Sa/Fr														38			1				6	2		9			1	Dwarf Elder
Sambucus cf. *ebulus*	Sa/Fr																					1							Dwarf Elder
Urtica dioica	Sa/Fr						1								1														Common Nettle
4 Ruderals/Segetals undiff.																													
Atriplex patula/hastata	Sa/Fr														4							4						1	Common-/Halberd-leaved Orache
Atriplex/Chenopodium	Sa/Fr														2							1							Orache/Pigweed
Chenopodium album	Sa/Fr			2		7	2			10	1	1			209		6	5841				210	1		41			8	Fat-hen

Site		Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
Chenopodium cf. *album*	Sa/Fr														4														Fat-hen
Chenopodium hybridum	Sa/Fr														1														Maple-leaved Goosefoot
Chenopodium spec.	Sa/Fr									1					1							1							Goosefoot
Echinochloa crus-galli	Sa/Fr										1				1													1	Cockspur
Galium aparine/ spurium	Sa/Fr														13														Cleavers goose-grass/False Cleavers
Matricaria perforata	Sa/Fr												1																Scentless chamomile
Solanum nigrum	Sa/Fr									1					2										3				Black Nightshade
cf. *Solanum nigrum*	Sa/Fr														1														Black Nightshade
Veronica hederifolia s. l.	Sa/Fr									1															11				Ivy-leaved Speedwell
Viola tricolor agg.	Sa/Fr																								1				Wild Pansy
5 Crops																													
Hordeum distichon/vulgare	Sa/Fr	1	9		4	1		1	2	8	17	12	22	9	604		17		1		2	12	1	21	16			2	Barley
Hordeum distichon/vulgare	Spi									1																			Barley
cf. *Hordeum distichon/vulgare*	Sa/Fr												5		73		1					2	5	2	1				Barley
Hordeum distichon/vulgare	Sa/Fr														10										3	599			Barley
cf. *Hordeum distichon/vulgare*	Sa/Fr														1														Barley
Secale cereale	Sa/Fr																								1				Rye
Triticum aestivum s.l./*durum/turgidum*	Sa/Fr	53	119	64	900	14				5	18	19			23		1	3		2					42		7	2	Free treshing wheat
Triticum aestivum s.l./*durum/turgidum*	Spi				7					4	3																		Free treshing wheat

Site		Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
Triticum cf. *aestivum* s.l./*durum*/*turgidum*	Sa/Fr	96		16						1					10		4	2				1							Free treshing wheat
Triticum dicoccum	Sa/Fr		23	40	244	46		1	1	12	23	11	3	5	1158		6	3		4		32	3	15	12			1	Emmer
Triticum dicoccum	HSB			3	93	72		20		29	61	4			536		4	1				1	5	31	2		10	2	Emmer
Triticum dicoccum	Spi										1																		Emmer
Triticum cf. *dicoccum*	Sa/Fr													1	53		4	1	1		1			9					Emmer
Triticum cf. *dicoccum*	HSB							3		2				7	35							1		1					Emmer
Triticum monococcum	Sa/Fr			18	83	2		1		2	8	8	1		159		3							11	18				Einkorn
Triticum monococcum	HSB			6	33	3	4	2		26	48	4	1		1486		4	20			49	13	1	102	3		64		Einkorn
Triticum monococcum	Spi																								2				Einkorn
Triticum cf. *monococcum*	Sa/Fr		2					1							15		4												Einkorn
Triticum cf. *monococcum*	HSB									1		1																	Einkorn
Triticum monococcum, 2-körnig	Sa/Fr														2		2												Einkorn, 2-grained
Triticum cf. *monococcum*, 2-körnig	Sa/Fr														5														Einkorn, 2-grained
Triticum spec., "new-type"	HSB														2														New glume wheat
Triticum durum/*turgidum*	Spi	25	1																										Free treshing wheat, tetraploid
Triticum aest. s.l./*dur.*/*turg.*/*dicoccum*	Sa/Fr			29														1						1					Free treshing wheat/emmer
Triticum dicoccum/*spelta*	Sa/Fr					1									12														Emmer/spelt
Triticum monococcum/*dicoccum*	Sa/Fr			1	2			1				7	3		49		18	2				1	1	17	2				Einkorn/Emmer
Triticum monococcum/*dicoccum*	HSB	2						41		7	6	2	6	2	3780		28	15			15	2		135	2				Einkorn/Emmer
Triticum monococcum/*dicoccum*	Spi														3		1												Einkorn/Emmer

Site		Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
Triticum spec., Spelzweizen	Sa/Fr												3		12														Glume wheat
Triticum spec., Spelzweizen	HSB													10	273		3						5						Glume wheat
Triticum spec., Spelzweizen	Spi														52														Glume wheat
Triticum spec.	Sa/Fr	9	23	200	514	107		6		3	13	10	5	9	766	2	23	7			2	5			5				Wheat undiff.
Triticum spec.	HSB	16		1																									Wheat undiff.
Triticum spec.	Spi			37											1														Wheat undiff.
Cerealia indet.	Sa/Fr	9	311	155	2	11	1	2	1	48	91	67	160	9	6261		96	10		1	4	63	24	145	242	127	6	8	Cereal
Cerealia indet.	BGF																								1				Cereal
Cerealia indet.	Hano												1																Cereal
Cerealia indet.	Spi														4			4											Cereal
Lens culinaris	Sa/Fr													6											3				Lentil
cf. *Lens culinaris*	Sa/Fr																					1							Lentil
Pisum sativum	Sa/Fr		1											4	15									1	4			2	Garden Pea
Pisum sativum	Hil														1														Garden Pea
cf. *Pisum sativum*	Sa/Fr														4														Garden Pea
Fabaceae (kult.)	Sa/Fr													2	5						2				1				Legumes
cf. *Linum usitatissimum*	Sa/Fr																								4				Flax
6 Weeds of root crops/gardens																													
Digitaria ischaemum	Sa/Fr														1														Smooth Finger-grass
Fumaria officinalis	Sa/Fr																								1				Common Fumitory
Setaria verticillata/viridis	Sa/Fr														2												1		Rough/Green Bristle-grass
cf. *Setaria verticillata/viridis*	Sa/Fr				1																								Rough/Green Bristle-grass
Stachys arvensis	Sa/Fr						1																						Field Woundwort
Stellaria media agg.	Sa/Fr																								2				Chickweed
Thlaspi arvense	Sa/Fr																								1				Field Penny-cress
7 Weeds of cereals																													

Site		Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
Bromus cf. *arvensis*	Sa/Fr																							1					Bromegrass
Bromus cf. *secalinus*	Sa/Fr														27							2							Chess grass
Galium spurium	Sa/Fr								1	1			1		15		7	1							1				False Cleavers
Galium cf. *spurium*	Sa/Fr		1																						2				False Cleavers
Polygonum convolvulus	Sa/Fr					2									36		88	64		1		18	1	2	3		3		Black bindweed
Polygonum cf. *convolvulus*	Sa/Fr														13							3							Black bindweed
Scleranthus annuus s.str.	Sa/Fr										11						1												Annual Knawel
Sherardia arvensis	Sa/Fr										1																		Field Madder
Valerianella locusta	Sa/Fr														1														Common Cornsalad
Vicia hirsuta	Sa/Fr														5														Hairy Vetch
Vicia hirsuta/tetrasperma	Sa/Fr	2	1			1	5																						Hairy/Smooth Vetch
Vicia cf. *hirsuta/tetrasperma*	Sa/Fr										1																		Hairy/Smooth Vetch
10 Deciduous forest/bushes																													
Cornus sanguinea	Sa/Fr						2								1														Common dogwood
cf. *Cornus sanguinea*	Sa/Fr																						1						Common dogwood
Corylus avellana	Sa/Fr	312	41	4	12	7	6	6	9	1005	235	8	9		1085			11		1	1	1	5	28	25			3	Hazel
cf. *Corylus avellana*	Sa/Fr								1			1																	Hazel
Malus cf. *sylvestris*	Sa/Fr	47								2					4	19													Crab Apple
cf. *Malus sylvestris*	Sa/Fr									1					10														Crab Apple
Malus/Pyrus	Sa/Fr														107														Apple/Pair
Moehringia trinervia	Sa/Fr						5																						Three-nerved Sandwort
Physalis alkekengi	Sa/Fr																								8				Japanese-lantern
Prunus spinosa	Sa/Fr		1												19														Blackthorn
Prunus spec.	Sa/Fr														5														Stone fruits

Site		Spiere SPIE	Maa-Vo MAAS	FR 82	FR 85	HA 11	HA 32	HA 230	T&R Aachen TR	Inden 9 IND 9	Koslar 10 KOS 10	Soest Altstadt SOEST	AK4 EZWA	AK10 ABNIE	AK42 DA	AK95 ERB	AK166 DORN	AK276 BNAU	AK280 HATT	AK281 KAP	AK312 GLAUV	AK320 HATT	AK322 LIM	AK331 MAIN	BRA BRA	ILS ILSFE	LBH	MIU	
Sample volume (l)		36,6	121	41,18	16,97	52	21	9,28	50,3	121,05	216,95	212,3	417,04	71,62	2523,65	0,21	143,9	125,5	21	158,68	50,5	115	458,5	41	30,35		10	85,08	
Number of features		4	1	2	6	7	5	4	9	10	24	5	10	4	47	1	1	6	1	12	1	10	37	5	11	3	1	1	
Number of samples		10	17	5	9	26	10	8	9	19	95	38	48	26	187	2	13	14	1	39	3	15	50	5	135	3	1	17	
	Rtype																												**English name**
Rubus fruticosus agg.	Sa/Fr		1		1	1			1	1																			Blackberry
Rubus idaeus	Sa/Fr														1														Raspberry
Rubus cf. *idaeus*	Sa/Fr																					1							Raspberry
Rubus spec.	Sa/Fr									1					6							3	1						Blackberry/Ras-pberry/Dewberry
Sambucus nigra	Sa/Fr						1																		2				European Elder
Sambucus nigra/ racemosa	Sa/Fr	1																							2				European/Red Elder
Sambucus spec.	Sa/Fr														88			1				8	2	6					Elder
11 Varia																													
Seeds/fruits	Sa/Fr	1	8		1	1	11	8	1	9	10	10	4	1	247		10	10	1	1	5	16	3		24		1		Seeds/fruits
Other plant remains	div.			113	3		160	11	39	293	1912	10	114		765	3	4					1	5						Other plant remains
Fish	Fisch																2	2											Fish
Bones	Knoz									2387	310		43	7	87	11	13	12				7	7	66					Bones
Coprolites	Kopr						6				3		43		23			13	1	1			10						Coprolites